CORRELATION OF RETURNS AND VOLATILITY AMONG US, JAPAN, AND ASIAN EQUITY MAKRETS

by

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ABSTRACT

The global equity markets have become more integrated regionally as well as globally with deregulations of trades among different countries and with advanced communication technology at low costs. The stock markets of the U.S., Japan, the former 'Four Asian Tigers', and Malaysia are chosen to demonstrate such a phenomenon. The results of this investigation help to understand the recent interdependence before and after the Asian financial crisis, and the common market effects and behaviours of the U.S. and Japan during the post-crisis period. Because of the heteroskedastic property of stock returns, the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) family of modelling process is used to study the correlation of returns and volatility. The analysis utilizes daily closing returns from the major stock exchanges of the individual markets from June 1995 to May 2000. The correlation of returns and volatility among stock markets of the U.S., Japan, Hong Kong, Singapore, and Malaysia is found to have increased since the 1997 Asian financial crisis. The U.S. and Japan are shown to have common economic market effect after comparing their individual and collective influences on the Asian markets. The U.S. has a stronger economic factor than Japan. Japan still plays an important role after the financial crisis on the Asian stock markets. If the Japanese market is another factor, Japan has to revive its own economy in order for the Asian markets to leave the current economic recession.

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ACKNOWLEDGMENTS

I choose this topic because I have experienced the 1997 Asian financial crisis: low stock prices, negative GDP growth, and high unemployment rate. The local government cannot do much about the current situation. Also, I am curious in our Financial Secretary's claim that Japan will help revive the economic development in Asia. Further, Dr. Raymond So of the Department of Finance challenged us to generate innovative ideas. So I choose GARCH, the term I first heard of from my class in International Financial Management.

Since I am not familiar with GARCH, I have to read computer manuals and try with data to see how they fit the model. I have tried many times to ascertain that I can use the software in an appropriate way.

I am indebted to Dr. Raymond So for his valuable comments and several reviews on my work. I benefit tremendously from discussion with him. In addition, I would like to thank Dr. Henry Mok of the Department of Economics and Decision Sciences for letting me know where I can use computer software for GARCH analysis. Finally, I have to thank my friends Ah Wai and Kevin Lim who helped me fix my old computer so that I could work on and finish this paper at my dormitory. Any errors are my own responsibility.

CHAPTER I

INTRODUCTION

In the recent Asian financial crisis, the currency devaluation first occurred in Thailand and Indonesia, causing widespread depreciation and devaluation of currencies in other major Asian countries. These shock waves also caused subsequent falling in stock prices in their stock markets. The Crisis has revealed a chain effect: financial performance in one market affects those of other markets in the same region. The following is an account of the 1997 performance of seven stock indices which will be the focus of this research project. The results of this investigation may provide insight into the regional and global correlation of the stock markets: the U.S., Japan, Hong Kong, Singapore, Malaysia, Taiwan, and Korea.

In 1997, the U.S. stock market showed robust growth. However, the Asian currency crisis rattled this country's market in late October. Investors were concerned about increases in market volatility and financial performance of U.S. companies in the Asian Pacific Region. After all, the Standard & Poors 500 Composite Index (S&P 500) had recorded a total return (including dividends) of 33.4% in the same year. At the same time, Japan was crippled by its sharply decelerating domestic economy and a disastrous financial system in the second half of the year. Together with the Asian Crisis, the Nikkei 225 Stock Index (Nikkei 225) dropped by 21% for the whole year. Hong Kong also experienced the currency crisis, with the crisis peak in October 1997.

The Hang Seng Index (HSI) fell by 34% from the end of July to the end of the year, and for the whole year, by 20%, removing the gain during the first half of the year. Like Hong Kong, Singapore was hard hit by the crisis as Thai Baht floated on 2 July. The Straits Times Industrial Index (STII) became stagnated, losing ground to the end of the year. The Index fell further in early 1998 from 2,126.8 to 1,529.8 in 1997, a 39% drop. The major stock index of Malaysia dropped by 57% during 1997. To limit the fall, the Kuala Lumpur Securities Exchange imposed the 'August-end Designation.' Trading activities of 100 'designated' stocks could only be done after they had been lodged with local brokers. Foreign traders were crippled by such change of policy. However, the strategy did not prevent the Kuala Lumpur Composite Index (KLCI) from further dropping by 14% over 5 days, but only until the restriction was relaxed. Taiwan had a favourable fundamental economy, showing an 18% increase in the Taipei Composite Index (TCI) during 1997. The highest was 10,116.84 on 26 August, but, from September, the index fell to 7,000-8,000 level as it met the Asian Crisis. Finally in Korea, the Korea Composite Stock Price Index (KOSPI) experienced a free fall in July as Thai Baht floated in early July 1997.

Empirical evidence of interdependence of financial markets in 1997 was no unique. Various studies on regional correlation of stock markets have been undertaken since 1970's. Hilliard (1979) finds that regional markets are becoming more affected by each other in times of major financial crisis and during wartime, e.g., the OPEC oil embargo in 1773. Von Furstenberg and Jeon (1990) suggest that stock markets have been increasingly correlated since 1986 due to deregulation. Koutmos and Booth (1995) find that bad news has strong influence on foreign markets. Chandrashekaran (2000) concludes that Asian markets are much more correlated. Other research includes Koch and Koch (1991), Masulis and Ng (1995), and Choudhry (2000b).

Nonetheless, the Asian financial crisis is the most frequently quoted example to show a more recently integrated regional and global stock markets.

To explain the empirical results, one of the theoretical frameworks accounts for possible interdependence of financial markets. Since regional financial markets have overlapping trading hours, important financial and economic news announced in one stock exchange immediately passes to other markets in the form of information. The information is then circulating simultaneously in all markets. This regional information as well as local news serves to govern the buying and selling behaviours of investors. In an efficient market, the investors utilize whatever news available until the market is closed. This hypothesis is consistent with those of Koch and Koch (1991) and Kim and Rogers (1995).

The same mechanism also works in the global markets with no overlapping of trading hours. Information spreads, for example, from the U.S. to Japan, and affects investment behaviours when the investors find such information important. The effect of information is then fully reflected in the market price of Japan. Therefore, opening price fluctuation is due to local news and world news. During the trading hours in Japan, intra-day volatility is better accounted for by local and regional news. Later the day, the stock index at Tokyo Stock Exchange is closed with a certain price level. What has happened in Japan will in turn affect the opening market price of the New York Stock Exchange the following day. This chain of information effect serves to connect the world's stock markets globally.

On the other hand, the empirical results for interdependence are dubious. Empirical research on global correlation includes Barclay, Litzenberger, and Warner (1990); Becker, Finnerty and Gupta (1990); Theodossiou and Lee (1993); Solnik, Boucrelle and Le Fur (1996); and Chandrashekaran (2000). Kyle (1985) finds that the knowledge of information processed by investors in one market affects the return and risk transmissions to other markets in the form of price volatility. As a result, information inter-relates the stock market indices by spreading itself out regionally and globally. Although Roll (1989) and Hamao et al. (1991) claim that the correlation between global markets has increased since 1987, Susmel and Engle (1994) find no evidence to support their claim. They cannot conclude that returns can be predicted by news because such effect is arbritaged away by the markets. That is, the same assets traded in different markets will have the same prices.

The Objectives

The aims of this research project are twofold. The first is to find out whether the correlation of returns and volatility between the major indices and Asian markets has increased since the financial crisis. The short-term effects of correlation and volatility are examined based on the stock markets of the U.S., Japan, and five selected Asian countries: Hong Kong, Singapore, Malaysia, Taiwan, and Korea. Solnik, Boucrelle, and Le Fur (1996) find that Asia has become more important in the world trend of correlation because they have explosive growth. Hong Kong, Singapore, Taiwan, and Korea are of interest as they have once been called the 'Four Little Tigers of Asia.' Therefore, their influence in Asia-Pacific region has been increasing, and has recently played an important role in the region. Malaysia is included because its economic competitiveness has shown dramatic improvement. To avoid confusion, such terms as 'Asian indices' or 'Asian markets' throughout this project do not include Japan since it has been put in a separate category. To restrict our scope of interest, any interactions among the Asian markets are not addressed as their forces are considered very small using the small country assumption. In addition, correlation of markets with overlapping trading hours is explained more by the International Capital Asset Pricing Model (ICAPM).

The second objective is to understand the extent to which price levels and price fluctuations in Tokyo Stock Exchange influence those in the Asian stock markets during the post-crisis period. Many believe that Japan's financial market serves the role of a vanguard in the recovery of the Asian economies. One of the major arguments relies on the fact that Japan is the second largest economy after the U.S. In terms of vicinity, Japan is close to Asia, and so it can cause regional economic growth in the Asian markets. On the other hand, other economists and financial analysts hold a different view, claiming that other economic factors such as the U.S. performance also count. The Wall Street Journal Europe had the following report abstract:

> The combination of a weakening yen, worries about the stability of Japanese banks and Wall Street's steep fall on Friday and poor opening Monday sent a chill wind through world stock markets.
>
> (Sesit 1998:11)

A better conclusion can be reached as to whether the recovery of Japan stock market can lead to a better share performance in other Asian markets based on correlation and volatility. The results of investigation help understand the role of Japan in the aftermath of the financial crisis.

In this research, stock indices of the selected stock markets from the past five years are examined using linear correlation analysis. The results are confirmed using the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) family of statistical process which is able to capture any tranquillity and volatility in the stock series. Empirical results suggest that the correlation among the U.S., Japan, Hong Kong, Singapore and Malaysia has increased since the crisis. Although the U.S. market affects the correlation more than Japan's market does, both countries are important in the correlation with the Asian countries. Moreover, Asian markets have contributed to more interdependence, implying an increase in their influence on the world's stock markets.

The chapters that follow are going to provide theoretical and empirical framework for investigating the interdependent relationship. Chapter II is a review of prior research on correlation of returns, volatility, properties of stock returns, application of the GARCH model, and Day-of-Week effect (DOW). Chapter III introduces the statistical theories and the ways to interpret empirical findings. Chapter IV describes the stock trading systems of the markets to be investigated, and has a brief discussion on index data. Chapter V is an account of the empirical findings. Finally, Chapter VI is a summary and conclusion of the research.

CHAPTER II

REVIEW OF LITERATURE

This chapter introduces different methodologies on the subjects by various scholars. Prior research on the first and second moment interdependence is numerous. Moreover, this chapter gives a summary of the literature on correlation of returns and of volatility, properties of stock returns, GARCH modelling, and DOW. These elements form the basis for methodologies of examining the data. Theoretical and empirical pieces of evidence are also provided.

Correlation of Returns among National Stock Indices

Correlation of returns is indicated by co-movement of price levels between two or more indices. Hilliard (1979) finds that North America and Europe have strong intra-continental commonality, even in the context of hourly co-movement in the indices. Eun and Shim (1989) find increased interactions among various stock markets using Vector Autoregression (VAR) model. They show that price transmissions begin from the U.S. to other markets, but other markets exert no effect on the U.S. market. Becker, Finnerty and Gupta (1990) prove that the correlation between lagged S&P 500 and Japan is strong in their regression analysis. The contagion theory of King and

Wadhwani (1990) is evident in the U.S., U.K., and Japan. Fischer and Palasvirta (1990) show that stock-market interdependence has grown by using cross-spectral analysis and coherence test on daily prices of various indices from 1986 to 1988. They also find that there is high correlation between the U.S. and other world indices. As a result, the two scholars hypothesize a 'world factor' which governs the co-movement of various stock markets. Koch and Koch (1991) conclude more interdependent markets in the same geographical region with trading hours overlapping. They find that better communication, increased capital mobility, and government policies have been the contributing factors to reduce imperfection in equity market. Theodossiou and Lee (1993) examine the interdependence of the U.S., Japan, UK, Canada, and Germany. Erb, Harvey, and Viskanta (1994); Granito (1994); and Longin and Solnik (1995) examine the correlation of various stock markets over time. Studies by Kim and Roger (1995) confirm the spillover effect from the U.S. and Japan to Korea in the announcement of open market in Korea. Solnik, Boucrelle and Le Fur (1996) propose that correlation of returns increases in periods of high volatility. Ng et al. (1991) have evidence to prove that the volatility spillovers in Pacific-Basin markets have increased. Chandrashekaran (2000) has shown that correlation has increased over 12 months within the Southeast Asian markets since the crash using linear correlation analysis. In addition, he witnesses a worldwide increase in correlation between equity markets. Bennet and Kelleher (1988), Roll (1989), Hamao et al. (1990), Susmel and Engle (1994), Lin et al. (1994), Karolyi (1995), and Koutmos and Booth (1995) examine correlation of returns. Engle et al. (1990) and Ito et al. (1992) suggest that the correlation of returns is caused by 'Meteor Shower' spillovers. Using correlation analysis, Choudhry (2000b) finds that Australia, Hong Kong, Japan, and Singapore have become more integrated after the 1987 crash.

The magnitude of correlation is of interest. Ferson and Harvey (1993); Kim and Rogers (1995); and Solnik, Boucrelle, and Le Fur (1996) empirically find that the cross-correlation of a small and a large market is smaller than that of two larger markets. For example, the correlation between the U.S. and Japan is expected to be larger than that between the U.S. and any of the Asian country.

Ripley (1973) investigates correlation of returns using multivariate correlation analysis among national markets. He offers three theoretical explanations for an integrated regional equity market. First, the similar income expectation indirectly links stock prices between countries. Second, dominant financial markets facilitate capital flows within the region, reducing interest rate differentials. Last, the arbritage process prevents price differentials of multinational firms' shares being traded in two different indices. Therefore, the stocks should have the nearly identical price behaviours within limits. Von Furstenberg and Jeon (1990) offer three factors to explain that the deregulation since 1986 has made markets increasingly correlated in returns. The first factor is related to the industry-specific global event. For example, rising oil price can trigger off economic anxiety in several countries at the same time. Another factor is the entire-economies global events such as money supply. The third factor is the reliance on any internal event such as economic fundamental that has great momentum without external cause.

Correlation of Volatility among National Stock Indices

Volatility or risk is measured by variance of stock returns. Individual return premium and volatility are driven by market volatility (e.g. Schwert and Seguin (1990)). Lin, Engle, and Ito (1991) suggest that the deviations of actual values from predicted values measure the prediction errors. Masulis and Ng (1995) find overnight information affect daytime volatility.

Empirically, Eun and Shim (1989) analyze the correlation of price as well as volatility using the VAR model. They find that Asian Pacific markets respond most strongly with a one-day lag; but the effect then fades rapidly. Most of the responses to a shock are completed within two days. Fischer and Palasvirta (1990) use Coherence test to measure the lead/lag relationship and find that the covariance relationship increases. Engle, Ito, and Lin (1990); and Ito, Engle, and Lin (1992) call volatility transmission to other foreign markets 'Meteor Shower.' Lin et al. (1991) find that volatility and return spillovers are reciprocal between the two markets. Lin et al. (1994) hypothesize that volatility and returns of two markets are related because of close trade and investment link. The volatility transmission by means of information is hypothesized by Kyle (1985), Von Furstenberg and Joen (1990), and Kim and Rogers (1995).

In addition, cross-country correlations are examined. Research done by Hamao, Masulis, and Ng (1990) finds that 'Volatility Surprise' to be realized in foreign markets is transmitted from the U.S. to Japan, from London to Japan, and from the U.S. to London after the 1987 financial crash. Using the same approach, Kim and Roger (1995) confirm the Surprise effect from the U.S. and Japan to Korea in the announcement of open market. A follow-up study by Theodossiou et al. (1997) has a similar result using weekly returns of a longer period between May 1984 and October 1994. Volatility spillover is found to export from the U.S. and Japan to U.K. On the other hand, Ng et al. (1991) find little support for spillover in Asian stock markets. In addition, Susmel and Engle (1994) have a different conclusion when they investigate hourly spillover between the U.S. and UK. Their results suggest that such spillover is minimal and that the duration lasts only an hour.

Research based on other methodologies supports the conclusion of a stronger spillover effect. Theodossiou and Lee (1993) find that the U.S. exports innovations to all other markets, and that innovations of Japan appear in Germany only. These spillovers can explain less than 6% of the total variation of returns in these markets. Koutmos and Booth (1995) examine the markets of New York, Tokyo, and London using daily returns between September 1986 and December 1993. Price spillover is found from New York to Japan and London, from Japan to London, and volatility spillover is exported from New York to London and Japan, from London to New York and Tokyo, and from Japan to London and New York. Harvey and Shephard (1996) also find correlation of volatility between the two selected indices. Solnik, Boucrelle, and Le Fur (1996) suggest that volatility contagion between markets has increased over time, and that conditional risk increases more than domestic variance when national volatilities increase.

Especially, Choudhry (2000b) concludes regional volatility and return transmissions in the Pacific-Basin markets have increased after the 1987 crash. Chandrashekaran (2000) witnesses a worldwide increase in volatility between equity markets after the Asian financial crisis. Volatility has not returned to the pre-crisis level, however. Even the less volatility of the U.S. market has increased by 2% per annum.

Both empirical and theoretical pieces of evidence suggest that the stock returns are correlated in terms of price level and volatility in different markets. This conclusion helps strengthen the validity of the results in this research.

Characteristics of Stock Returns

Stock returns are characterised by volatility clustering, skewness, excess kurtosis (e.g. Mandelbrot (1963, 1967) and Jaffe and Westerfield (1985)), and serial correlation (e.g. Fisher (1966), LeBaron (1992), and Booth and Koutmos (1998)). Connolly (1989) and de Jong et al. (1992) find that most stock analyses assume a normal distribution in the error term and return with constant variance. Connolly (1989) and Booth and Koutmos (1998) propose that the error term generated by regression is not normally distributed. Stocks of small market capitalisation especially tend to show first order serial correlation coefficients since the stocks do not trade frequently. Mandelbrot (1963) find autocorrelation in stock returns. Fama (1965) also find serial correlation in industrial stocks of the U.S. Fisher (1966) and Scholes and Williams (1977), Cohen et al. (1980), Chelley-Steeley and Steeley (1996), and Koutmos and Booth (1995) suggest that autocorrelation is partial due to non-synchronous trading. Scholes and Williams (1977) and Lo and MacKinley (1988) suggest transaction costs and delayed responses cause autocorrelation. They provide a theoretical explanation. Since trading is not continuous, prices are not adjusted immediately to new information. For example, if the stocks are traded at time *t*, new price level is adjusted according to the price level at time *t-1*. The observed prices reflect news with a lag news coming at the end of the trading day. New prices on the next day then reflect yesterday news. Therefore, today's price and past price are serial correlated. French, Schwert, and Stambaugh (1987) examine the relation between return and volatility, and find that returns show autocorrelation. Lo and MacKinley (1988) find autocorrelation in stock violates the Random Walk hypothesis. Akgiray

(1989) and Koch and Koch (1991) find substantial autocorrelation in most returns series.

GARCH Estimation

The GARCH Model, pioneered by Engle (1982) and later generalised by Bollerslev (1986), has been extensively used in various studies to examine volatility of stock returns. French, Schwert, and Stambaugh (1987) examine the relation between return and volatility. Lee and Ohk (1991) find a strong ARCH effect in the stock returns of Hong Kong, Japan, Taiwan, and Korea. Bollerslev, Chou, and Kroner (1992); and Masulis and Ng (1995) successfully test volatility on stock returns. Chelley-Steeley and Steeley (1996) use the model to examine volatility of stock portfolios. Nandi (1998) uses GARCH in price volatility for options.

One of the uses of the model is to examine the properties of stock returns. French et al. (1987), Chou (1988), Akgiray (1989), Baillie and DeGennaro (1990), Kim and Kon (1994), and Choudhry (2000a, 2000b) find that the model can capture volatility clustering, skewness, and leptokurtosis. All are general characteristics of stock returns. Therefore the GARCH model is appropriate to examine stock returns.

Also, the model can investigate individual and multiple stocks. Hamao, Masulis, and Ng (1990); Susmel and Engle (1994); Kim and Rogers (1995); and Chandrashekaran (2000) use GARCH to model individual return's volatility. Hamao, Masulis, and Ng (1990); Ito, Engle, and Lin (1990); Theodossiou and Lee (1993); Lin, Engle, and Ito (1994); Koutmos and Booth (1995); and Theodossiou et al. (1997) examine volatility between various national stock markets. Measures of regional and global volatility are modelled based on GARCH by Bollerslev, Engle and Woldridge (1988), Masulis and Ng (1995), and Donaldson and Kamstra (1997).

Besides, the model can be used to show forecasting on return data. Engle and Bollerslev (1986); Donaldson and Kamstra (1997); Song, Liu, and Romilly (1998); and Chandrashekaran (2000) use GARCH to forecast volatility so successfully that the model is a suitable statistical tool for volatility analysis.

Day of Week Effect

High Friday returns and low Monday returns is called Day of the Week Effect (DOW). DOW is found to affect correlation of returns and volatility. Keim and Stambaugh (1984) find low returns on Monday partially due to positive errors in prices on Friday. If the errors vary over time, higher Friday price produces lower Monday price. So there is measurement error in portfolio returns. Empirical results by Agrawal and Tandon (1994) shows that Friday has higher returns from the U.S. market.

On the other hand, Fama (1965) and Godfrey et al. (1964) propose that return variance is higher on Monday for the U.S. market. French (1980) states that Monday returns should be three times more than any other weekday if information accumulates at a constant rate over time. Therefore, variance increases three times from Friday to Monday. French and Roll (1986), Barclay et al. (1990), and Foster and Viswanathan (1990) find that Monday has the maximum information. Thus, between Tuesday and Thursday, variance decreases as public information arrives. On Friday, private information is least useful. Therefore, traders are more sensitive to changes in order flow on Monday. Monday volatility should be positive while Friday volatility should be negative. Fortune (1991) argues that government and firms release good news during trading period while storing up bad news after Friday close. Investors cannot react until Monday opening. Choudhry (2000) finds Monday effect on volatility of Malaysia. Jaffe and Westerfield (1985a) find DOW in Japanese market. Choudhry (2000) finds DOW in emerging markets such as Taiwan and Korea. Such effect on the emerging may have come from Japan.

Because of the DOW effect on stock returns, the GARCH model has to take into account its effect when examining stock returns.

Major scholastic literature has documented different results of investigations on returns. All the evidence quoted suggests that correlation of returns and volatility increase over time. Although much research has been done to prove that the global markets are more correlated, little research is being done on emerging markets with major indices. Even less research has focused on Asian markets during the Asian financial crisis. If such relationship is found to exist, the results help to prove that the crisis was not a coincident phenomenon. Furthermore, this analysis is conducted with a view to identifying patterns of interdependence that correlate different markets and understanding a global view of economic development and investment portfolio decision. Chapter III has a detailed discussion on the methodology used for the stock index analysis.

CHAPTER III

METHODOLOGY

This chapter delineates the methodology of examining various stock indices to obtain the empirical results. The first part of this chapter is to have a look at the summary statistics of the stock data to identify the three properties of stock returns: skewness and excess kurtosis, volatility clustering, and autocorrelation. Cross-index correlation analysis that follows provides a preliminary check on the relationship between returns of the markets. Then, the GARCH family of statistics process for returns modelling is discussed.

Summary Statistics

The distribution pattern of return data described by Summary Statistics is the first step in examining the return time series. The statistics provide a brief overview of the return series properties to decide on what statistical models to be used for modelling volatility. Mean, Median, Standard Deviation, Skewness, Kurtosis, Jarque-Bera test statistic, and autocorrelation are useful in giving a preliminary picture of the return data.

Mean is the average value of the stock return series. The value is given by sum of the measurements divided by the number of observations of the returns.

$$\overline{R}_i = \frac{\sum_j R_{i,j}}{T} \tag{3.1}$$

where $R_{i,j}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, are the index returns; and

T is the number of observations.

Median is the middle value of the stock return series when the values are ordered from the smallest to the largest.

Standard Deviation is a statistical measure of variability of the stock return series:

$$s = \sqrt{\frac{\sum_{j=1}^{T}(R_{i,j} - \overline{R}_i)^2}{T-1}} \tag{3.2}$$

where $R_{i,j}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, are the index returns;

$\overline{R}_i$ is the mean value; and

T is the number of observations.

Skewness measures the degree of the asymmetric distribution of the stock return series around its mean:

$$Sk = \frac{1}{T}\sum_{j=1}^{T}\left(\frac{R_{i,j} - \overline{R}_i}{s^2}\right)^3 \tag{3.3}$$

where $R_{i,j}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, are the index returns;

$\overline{R}_i$ is the mean value;

T is the number of observations; and

s is the standard deviation.

For a normally distributed stock return series, it has a skewness value of zero, and is distributed as $N(0, 6/T)$. A positive value of skewness indicates that the distribution of returns is right-skewed; a negative value shows a left-skewed distribution.

Kurtosis is a measurement of the heaviness of the distribution tails of the return series. The definition of kurtosis involves the fourth powers of standard deviations, and is given by:

$$K = \frac{\dfrac{\sum_{j=1}^{T}(R_{i,j} - \overline{R}_i)^4}{T}}{\left(\dfrac{\sum_{j=1}^{T}(R_{i,j} - \overline{R}_i)^2}{T}\right)^2} \tag{3.4}$$

where $R_{i,j}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, are the index returns;

$\overline{R}_i$ is the mean value; and

T is the number of observations.

The coefficient of kurtosis is approximately distributed as $N(3, 24/T)$ if the returns follow a bell-shaped distribution. A symmetric distribution with heavier tails than a bell-shaped distribution has a coefficient greater than 3.0; a light-tailed distribution has a value less than 3.0.

Jarque-Bera statistic is used to test whether the return series follows a normal distribution. This test measures the difference of the skewness and kurtosis of the return series with those of a normal distribution. The Jarque-Bera statistic follows the chi-square χ^2 distribution with two degrees of freedom under the null hypothesis of a normal distribution.

$$JB = \frac{T-k}{6}\left(Sk^2 + \frac{(K-3)^2}{4} \right) \qquad (3.5)$$

where T is the number of observations;

k is the number of estimated coefficients used to create the returns series;

Sk is the skewness; and

K is the kurtosis

Various researchers have examined the statistical distribution of stock returns. Mandelbrot (1963, 1967), Fama (1965), Westerfield (1977), and Kon (1984) suggest that stock returns are not normally distributed. Mandelbrot (1963) finds the returns exhibit volatility clustering. Jaffe and Westerfield (1985b), for example, find stocks of Japanese markets have a skewed distribution. French, Schwert, and Stambaugh (1987), Theodossiou and Lee (1993), Koutmos and Booth (1995), and Song, Liu, and Romilly (1998) find that stocks show conditional heteroskedasticity. In general, the stocks exhibit the properties of leptourtosis, skewness, and volatility clustering. All these characteristics are not the properties found in a Gaussian distribution.

Autocorrelation

Autocorrelation exists when the return's mean is not zero, and its variance is not constant. Stock returns may be correlated with previous returns. Positive (negative) returns are likely followed by positive (negative) returns. Autocorrelation of a return series is given by:

$$r_k = \frac{\sum_{t=k+1}^{T}(R_{i,t} - \overline{R}_i)(R_{i,t-k} - \overline{R}_i)}{\sum_{t=1}^{T}(R_{i,t} - \overline{R}_i)^2} \tag{3.6}$$

where $R_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, are the index returns;

$\overline{R}_i$ is the mean value; and

T is the number of observations.

A series follows a low-order autoregressive (AR) process if the coefficient decreases with increasing lag k. Otherwise, it obeys a low-order moving-average (MA) process if the coefficient drops to zero after a few lags. A rough approximation for the standard error can be taken by computing $\pm 1/\sqrt{T}$ (assuming the true auto-correlation is zero). When any of the coefficients suddenly drops within $\pm 1/\sqrt{T}$, the coefficient is not significantly different from zero at the 5 per cent significant level (e.g. Akgiray (1989)).

For the test of cumulative autocorrelation, the Ljung-Box (1978) Q-statistic at lag k is a test statistic for the null hypothesis that no autocorrelation exits up to order k:

$$Q_{LB} = T(T+2)\sum_{j=1}^{k}\frac{{r_j}^2}{T-j} \tag{3.7}$$

where r_j is the j-th autocorrelation coefficient; and

T is the number of observations.

McLeod and Li (1983), Bollerslev et al. (1992), and Booth and Koutmos (1998) suggest that the Q-statistic follows the chi-squared distribution under the null hypotheses that the return series is a random walk. The degree of freedom is equal to the number of autocorrelations. If the value of Ljung-Box Q(k) is greater than the critical value, the null hypothesis that the returns are independent is rejected.

Detection of any autocorrelation from lag 1 to lag 12 is conducted on returns with levels and squares of returns based on the Ljung-Box Q(12) statistic. The statistic is often used to test for serial correlation in a stock time series.

Linear Cross-index Correlation Analysis

Cross-index correlation measures the strength of the economic influence between two stock markets. Assume that the stock returns of two financial series are discrete random variables with their own standard deviations. The definition of the correlation is given by the following equation:

$$Corr(R_i, R_l) = \frac{\sum_{j=1}^{T}(R_{i,j} - \overline{R}_i)(R_{l,j} - \overline{R}_l)}{(T-1)s_{R_i}s_{R_l}} \qquad (3.8)$$

where R_i and R_l, i,l = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, $i \neq l$, are the index returns;

$\overline{R}_i$ and $\overline{R}_l$ are the mean values;

T is the number of observations; and

s is the standard deviation

The coefficient of correlation reveals a linear relation with a value ranging from −1.0 to +1.0. When the two indices are independent, their correlation coefficient is zero. A value of one indicates the maximum strength of co-movement. A positive coefficient shows that the two indices increase or decrease together in the same direction. A negative coefficient shows that when one index increases, the other decreases. The correlation between two stock returns reveals a linear relation only. While the corresponding p-value reveals the possibility of the occurrence of the influence, a large p-value shows that the coefficient is not significantly different from zero. This is because the possibility is not stable enough over time to allow much statistical confidence in measuring the economic impact.

The correlation discussed above represents the returns in levels. Correlation between squares of two returns, which is an approximation to correlation of volatility, is also examined (e.g. Susmel and Engle (1993)). A high value of coefficient over a long period reveals an important economic relationship, whereas a high value over a shorter period reveals a short-term dependence. Fisher and Palasvirta (1990) and Kim and Rogers (1995) successfully test for various national stock markets to explore their independence. Correlation measures a linear relation only between two markets. For the same reason, the test does not provide a very good picture of the real-world markets where variances of stock returns change over time. To strengthen the conclusion that the national stock markets have become more integrated, the GARCH model is employed to test for volatility.

GARCH Family of Modeling Process

The GARCH model is generalised by Bollerslev (1986) on the basis of the ARCH which is introduced by Engle (1982). The former assumes that variance and mean volatility are conditional. The model allows the conditional variance to be a function of past information set $(\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$.

GARCH can carry out financial time series analysis with the conditional variance changing over time. It can account for return data which have a heavily tailed distribution and volatility clustering. However, the model does not allow for serial correlation in the conditional error. In addition, the model assumes that the conditional variance has no stochastic component, and is a linear function of past squared errors or independent variables. ARCH (p) Model, where conditional variance is a linear function of past squared errors, is represented by:

$$R_{i,t} = \alpha_0 + \varepsilon_t \tag{3.9}$$

$$h_t = \beta_0 + \sum_{j=1}^{p} \gamma_j \varepsilon_{t-j}^2 \tag{3.10}$$

where $R_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, & KOSPI, are the returns;

α_0, β_0, and $\gamma_j, j = 1, 2, \ldots p$, are constant parameters;

ε_t and ε_{t-j}, $j = 1, 2, \ldots p$, are the errors. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:

$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$; and

h_t is the conditional variance at time t conditioning on all information available at the beginning of time t.

In addition, GARCH allows conditional variance to be a function of last period's squared errors and its conditional variance. GARCH (p, q) Model is represented by:

$$h_t = \beta_0 + \sum_{i=1}^{q} \phi_i h_{t-i} + \sum_{j=1}^{p} \gamma_j \varepsilon_{t-j}^2 \tag{3.11}$$

where β_0, ϕ_i, $i = 1, 2, \ldots q$, and $\gamma_j, j = 1, 2, \ldots p$, are constant parameters;

ε_{t-j}, $j = 1, 2, \ldots p$, is the error. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:

$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$; and

h_t and h_{t-i}, $i = 1, 2, \ldots q$, are the conditional variances at time $t(t-i)$ conditioning on all information available at the beginning of time $t(t-i)$.

From (3.11), the conditional mean and conditional are predictable from its last period's conditional variance as well as from its last period's squared error. β_0, ϕ_i, and γ_j have to have a value over zero because of non-negative nature of variance by definition. The coefficients ϕ_i and γ_j are a measurement of persistence of shocks to volatility. The sum of the coefficients ϕ_i and γ_j must be less than one. Engle and Ng (1993), Poon (1994), and Masulis and Ng (1995) suggest that the past volatility shocks have a positive but a decreasing effect on future volatility over time. The rate of dying out depends on the value of β_1 and β_2. If $\beta_1 = \beta_2 = 0$, the series is a white noise which implies Random Walk with $\sim N(0, \sigma^2)$. Moreover, when volatility is high (low), it is followed by a high (low) volatility. This process is called volatility clustering, e.g. Mandelbrot (1963) and Schwert (1989), and Theodossiou and Lee (1995); but the sign of price change cannot be predictable. Akgiray (1989) find Bollerslev's assumption of conditional variances depending on past realised variances and volatility clustering proves to be consistent with the volatility pattern of the U.S. market index. The GARCH model has been used to measure and predict stock returns by Akgiray (1989), and Baillie and DeGennaro (1990). In addition, the model is more efficient in parameter estimation than the Ordinary Least Squares (OLS).

GARCH-in-Mean Model

The relationship between market expected returns and volatility is of interest. As the risk increases, the expected returns also increase. Therefore, expected returns can be expressed as a function of variance. The Capital Asset Pricing Model (CAPM) states that there is a linear relationship between expected returns and standard deviation of returns (risk). Engle, Lilien and Robins (1987); and Bollerslev, Engle, and Wooldridge (1988) extend the GARCH to allow the conditional mean to be a function of the conditional variance at time t. Therefore, GARCH (p, q) becomes GARCH (p, q)-in-mean (GARCH (p, q)-M) by adding conditional variance in the mean equation. The mean equation is represented by:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t + \varepsilon_t \qquad (3.12)$$

where $R_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, & KOSPI, are the returns;

α_0 and α_1 are constant parameters;

h_t is the conditional variance at time t conditioning on all information available at the beginning of time t; and

ε_t is the error. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:

$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$

Bollerslev, Engle, and Wooldridge (1988) find a positive relationship between expected return and risk. On the other hand, no relationship is found between return and risk by Poterba and Summers (1986); French, Schwert, and Stambaugh (1987); Baillie and DeGennaro (1990); Chelley-Steeley and Steeley (1996); and Theodossiou and Lee (1995). Therefore, they suggest that the CAPM may not be a valid model.

MA(1)-GARCH (p, q)-M

A further assumption can be made on GARCH (p, q)-M. As the model has been mentioned not to allow for serial correlation in the conditional error, any serial correlation in the series must be identified, and taken out from the mean return through a moving-average (MA) process (e.g. Bollerslev (1987) and French, Schwert, and Stambaugh (1987)). MA can detect and remove serial correlation error for each order to see which is best fit. Since MA is needed for small capitalisation markets such as Taiwan and Korea (e.g. Lee and Ohk (1991), Kims and Rogers (1995)), MA is included in the model for completeness. Scholes and Williams (1977) and Cohen et al. (1980) show that Serial correlation is due to bid-ask spreads, non-synchronous trading of individual stocks, or minimum sized price changes. If MA(1) is best fit for the data, keep MA(1) until a higher form of MA is more appropriate. The mean equation including MA process now becomes:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t - \alpha_2 \varepsilon_{t-1} + \varepsilon_t{}^{1} \quad (3.13)$$

where $R_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, & KOSPI, are the returns;

α_i, i = 0,1, and 2, is a constant parameter;

h_t is the conditional variance at time t conditioning on all information available at the beginning of time t;

ε_t is the error. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:

$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$; and

ε_{t-1} is the one lag value of ε_t.

French, Schwert, and Stambaugh (1987), Hamao et al.(1990) and Susmel and Engle (1994) find this model the most suitable one to use in returns analysis.

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1 The negative sign before $\alpha_2\varepsilon_{t-1}$ is conventional.

MA(1)-GARCH (*p*, *q*)-M with Exogenous Variables

The model can allow for a DOW dummy variable and one or more of squared residuals (Volatility Surprise) as independent variables on the conditional mean and variance of an index return being investigated. The term 'Volatility Surprise', first pioneered by Hamao, Masulis, and Ng (1990), examines the short-term interdependence of price volatility across New York, London, and Japan. The Volatility Surprise is the most recent lagged squared error which represents an unexpected return of a foreign market to be realised in a domestic market after the foreign market has closed. A two-step approach is employed for Volatility Surprise. Step one is to get non-standardised residuals of the individual stock market indices. The next step is to square the residuals. They are then put into conditional mean and variance equations of domestic markets to get coefficients of the residuals. Hamao, Masulis, and Ng (1990) employ this strategy to test for volatility between different markets. Kim and Rogers (1995); Song, Liu, and Romilly (1998); and Choudhry (2000b) examine Volatility Surprise involving small capitalisation markets. Chelley-Steeley and Steeley (1996) examine volatility transmissions within portfolios of U.K. stocks. Since co-movement of returns is also affected by volatility, the squared residuals can be put in the mean equation, as suggested by Kyle (1985) and King & Wadhwani (1990). Equations 3.14 and 3.15 include the variables of DOW and Volatility Surprise from foreign stock markets:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \sum_{k=1}^{w} \lambda_k \varepsilon_{f,t-k}^2 - \alpha_3 \varepsilon_{t-1} + \varepsilon_t \tag{3.14}$$

$$h_t = \beta_0 + \sum_{i=1}^{q} \phi_i h_{t-i} + \sum_{j=1}^{p} \gamma_j \varepsilon_{t-j}^2 + \eta D + \sum_{k=1}^{w} \lambda_k \varepsilon_{f,t-k}^2 \tag{3.15}$$

where $R_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, & KOSPI, are the returns;

α_i, $i = 0,1, \ldots 3$, β_0, ϕ_i, $i = 1, 2, \ldots q$, and γ_j, $j = 1, 2, \ldots p$, η, and λ_k, $k = 1, 2, \ldots w$, are constant parameters;

D is the DOW dummy variable. D is equal to one for day following a weekend (D = 1) and zero for other weekdays (D = 0);

h_t and h_{t-i}, $i = 1, 2, \ldots q$, are the conditional variances at time $t(t-i)$ conditioning on all information available at the beginning of time $t(t-i)$;

ε_t and ε_{t-j}, $j = 1, 2, \ldots p$, are the errors. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:

$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2},\ldots) \sim N(0, h_t)$;

ε_{t-1} is the one lag value of ε_t; and

$\varepsilon_{f,t-k}^2$, f = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, and KOSPI, $k = 1, 2, \ldots w$, are the lagged squared residuals.

Two kinds of risks are identified: one from its own market and others from foreign markets. Since DOW is a cyclical effect occurring every week, MA(5) cannot remove the Monday effect. To account for such effect on the returns and volatility, a DOW dummy is included in all GARCH models. Keim and Stambaugh (1984) and Agrawal and Tandon (1994) suggest that Friday is expected to be positive DOW. French and Roll (1986) and Foster and Viswanathan (1990) suggest Monday is expected to be positive DOW. The DOW is tested in mean and in variance equations of the full period and the sub-periods (see Chapter IV).

Besides DOW, 'Volatility Surprise' is assigned from the U.S. and Asia to Japan, from Japan and Asia to the U.S., and from the U.S. and Japan to individual Asian countries. Since the influence of S&P 500 and Nikkei 225 on Asia is of interest, any interactions among the Asian markets are assumed to be small when compared with S&P 500 or Nikkei 225. In addition, they have overlapping trading hours (which will be discussed in Chapter IV). Correlation is expected to be positive and high based on ICAPM for efficient markets. Therefore the correlation among Asian markets are not going to be discussed. The model can also be used to examine any common market effect between the U.S. and Japan during post-crisis period (e.g. Hamao, Masulis, and Ng (1990)). If such effect exists between the U.S. and Japan, addition of either one of the exogenous residuals together will add no incremental influence on the mean and variance equations of the Asian indices. Coefficients of the squared residuals of S&P 500 and Nikkei 225 are compared for any change in magnitude and in significant level. Then, any common market effect can be inferred. The coefficients of residuals reflect the strength of economic influence from foreign markets. The larger the value of coefficient, the stronger the effect is on Asian markets.

Mis-specification Tests

Mis-specification of the models is determined by looking at the summary statistics of the normalised residuals, $\varepsilon_t/\sqrt{h_t}$, and normalised squared residuals, ε_t^2/h_t . Skewness and kurtosis show the degree of normal distribution. Measures for skewness and kurtosis are normally distributed as $N(0, 6/T)$ and $N(3, 24/T)$, where T is the number of observations. In general, the residuals should show more normal distribution than those of corresponding expected returns. Besides, any evidence of non-serial correlation is also investigated. The Ljung-Box Q statistic is used to test for autocorrelation in the normalised residuals and squared residuals (e.g. Koutmos and Booth (1995)). A test for the normalised squared residuals is necessary because Granger and Anderson (1978) observe that some of the series modelled in Box and Jenkins (1976) exhibit autocorrelation even when normalised residuals do not show such property. If the value of Ljung-Box Q(k) is smaller than the critical value at significant level, the null hypothesis that the residuals are independent cannot be rejected. Absence of serial correlation in the normalised squared residuals implies the lack of need for a higher order ARCH process.

All of the GARCH models previously mentioned are tested for fit to find the most parsimonious model of estimation for the returns. Numerical maximum likelihood is being used. The Log-likelihood function is given by:

$$L(\Theta) = \sum_{t=1}^{T} -\frac{1}{2}(\ln h_t - \frac{\varepsilon_t^2}{\sqrt{h_t}}) \qquad (3.16)$$

where Θ is the vector of parameters to be estimated;

T is the number of observations;

h_t is the conditional variance at time t conditioning on all information available at the beginning of time t; and

ε_t is the error. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:

$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$.

The function assumes that ε_t is normally distributed. Marquardt algorithm is used to maximize $L(\Theta)$ with the R-squared convergence criterion at 0.001 in all cases. Akaike Information Criterion (AIC) and Schwarz Critierion (SC) are reviewed for fitness of the models.

CHAPTER IV

NATIONAL STOCK MARKET INDEX AND DATA

This chapter consists of two parts. The first part is a brief introduction of the features of seven Stock Exchanges and their trading structures. The other part concentrates on the data and its transformation.

National Stock Indices and Trading Mechanisms[2]

The mechanism of trading affects the correlation of returns and volatility among the countries (e.g. Kim and Rogers (1995)). Since different stock markets have different trading hours and trading mechanisms (Refer to Table 1 on the trading hours of the Exchanges), a review of the trading structures of individual Stock Exchanges helps understand the similarities and differences between them.

In the U.S. stock market, S&P 500 Index is a value-weighted index composed of 500 firms, representing 76% of total market capitalisation. The U.S. market has the world's largest share market value. The New York Stock Exchange has a centralised continuous auction on the trading floor. SuperDot, the electronic device system, links member firms to the trading floor. During trading, brokers buy and sell orders for

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[2] Refer to 'The Salomon Smith Barney Guide to World Equity Markets 1998' published by Euromoney Books for a comprehensive review of the market information and data.

their customers. The largest membership is that of commission brokers. They are in one of the about 500 securities houses executing orders at agreed commission rates. Other brokers includes independent floor brokers who assist in trading other large orders, registered traders who trade on their own accounts, and specialists who trade on designated stocks.

TABLE 1

OPENING AND CLOSING TIMES OF THE STOCK EXCHANGES

Country	Stock Exchange	Index	Opening - Closing Time		Opening - Closing Time	
			Local Time		New York Eastern Standard Time	
U.S.A.	New York	S&P 500	9:30AM	4:00PM	9:30AM	4:00PM
Japan	Tokyo	Nikkei 225	9:00AM	3:00PM	7:00PM	1:00AM
Hong Kong	Hong Kong	HSI	10:00AM	3:55PM	9:00PM	2:55AM
Singapore	Singapore	STII	9:00AM	5:00PM	8:30PM	4:30AM
Malaysia	Kuala Lumpur	KLC	9:00AM	5:00PM	8:30PM	4:30AM
Taiwan	Taipei	TCL	9:00AM	12:00PM	8:00PM	11:00PM
Korea	Soeul	KOSPI	9:30AM	3:00PM	8:30PM	2:00AM

In Tokyo Stock Exchange (TSE), Nikkei 225 Stock Index is the most comprehensive, most diversified, and most representative stock index of all indices in Japan. It covers 225 firms among the major industries. It is a price-weighted index, representing 52% of total market capitalization. TSE is a two-way continuous auction market trading under zaraba method which is similar to an open outcry system. At the beginning of trading session, the price is established based on orders placed by regular members before the trading. The 150 most active stocks are traded on the trading floor using Computerized Order-Routing and Execution System (CORES). All securities must be traded through an authorized securities dealer who is a member of the Japan securities Dealers' Association. A saitori member, an agent of the Exchange, functions as the go-between.

In the Hong Kong Stock Exchange (SEHK), HSI covers 33 largest market capitalised stocks traded on SEHK. It is a weighted-average index, and is strongly influenced by stocks of large capitalisation called Blue-chip shares such as the Hong Kong and Shanghai Bank Corporation (HSBC) and the Hutchison Whampoa Ltd. It has been the most widely used economic indicator among the HSI family. SEHK trades on an order-driven trading system where trades originate from a client order, either a market order or a limit order. Dealers represent their customers on stock trading. All trading is completed through the Automatic Order Matching and Execution System (AMS). Investors place an order with a broker. The broker then calls a floor trader who enters the order into the AMS.

In the Singapore Stock Exchange (SSE), STII is the most widely observed indicator. The index has 30 constituent stocks. SSE adopts the LOB trading system, a computer network by which brokers and the trading workstations are linked. Brokers represent their customers in the trading process. The computer matches buy and sell orders. Each order has a limit price within which to trade. Orders are held according to price and time priority.

In Malaysia, KLCI computes 11 other local indices to show economy performance. The system for Computerised Order-Routing and Execution (SCORE) has replaced the traditional open outcry method of trading. Trading is executed by publicly or privately owned member companies. They have to have a minimum paid-up capital of RM 20 million. Foreigners can hold any interest limited to 30% (40% with approval of Ministry of Finance). The limit of price change is 30% of previous day's closing day's price.

For Taiwan, TCI is a weighted share price index similar to those of S&P500 and Nikkei 225. All trading must go through the Stock Exchange. Most are traded through a computerised system called the Fully Automated Trading System (FAST). Brokers are connected to the mainframe of the Exchange. Trading prices are traded within 7% of previous trading day's closing price.

For the Korea Stock Exchange (KSE), quotes of KOSPI are supplemented by section indices, industrial sector indices, and indices by capital size. A computerised system called the KSE Automated Trading System (KATS) has been in use since September 1997. Like SEHK, KSE is an order-driven market where buying and selling orders compete for the best price. Prices are matched according to price and time priority. Orders are submitted over a limited time period, and are matched at a single price to minimise imbalances between buyers and sellers. Daily price change is limited to 8% of previous day's closing price.

Stock Return Data and Data Transformation

Quotes of stock market indices are obtained from Datastream Inc. Seven stock indices are used to represent each country: S&P 500 for the U.S., Nikkei 225 for Japan, HSI for Hong Kong, STII for Singapore, KLCI for Malaysia, TCI for Taiwan, and KOPSI for Korea. A 5-year period is investigated from 1 June 1995 to 31 May 2000, consisting of 1304 observations of daily close-to-close prices. A full sample period and two sub-sample periods are examined. Since the Asian financial crisis begins in July 1997, this day is chosen as a cut-off day for dividing the pre- and post-crisis periods. To be more specific, the pre-crisis period represents a period from 1 June 1995 to 1 July 1997. The post-crisis period lasts from 2 July 1997 to 31 May

2000. The pre- and post-periods have 543 and 761 observations respectively. Table 2 presents a summary of the data.

TABLE 2

SAMPLING PERIODS AND OBSERVATIONS OF THE STOCK INDICES

Period	Starting	Ending	No. of Observations
Full	1 June 1995	31 May 2000	1304
Pre-Crisis	1 June 1995	1 July 1997	543
Post-Crisis	2 July 1997	31 May 2000	761

Earlier studies by Hamao, Masulis and Ng (1990) and Kim and Rogers (1995) have divided the index returns into 2 components: close-to-open and open-to-close daily returns. Their approach can carefully eliminate any overlapping of trading hours between two markets. It implies that any correlation of returns and volatility between two markets is not due to CAPM but Surprise effect.

Moreover, the U.S. has no overlapping trading hours with Japan or Asian countries. Correlation is expected to be positive and strong between countries with overlapping trading hours as predictable by ICAPM for efficient markets. All the selected Asian markets have similar trading hours. Surprise effect is difficult to be investigated. Therefore it is not going to be discussed. In addition, overlapping of trading hours causes lower volatility than that without overlapping (eg. Theodossiou et al. (1997)). Japan has several trading hours overlapping with those of all Asian countries. Therefore, the Surprise effect may be smaller than expected.

Since data on hourly change of index is not available, close-to-close daily index price is used to simplify the analysis. This approach assumes that there is no overlapping of trading hours. Therefore, estimation of the means and variances is assumed to be conditional on one's own past information and information from past foreign markets (e.g. Koutmos and Booth (1995)). Moreover, in some of the Asian markets, the Stock Exchanges impose a price-change limit which also causes autocorrelation in price. The price limit causes artificial low volatility, which spread out to several days. Investors may need more time to realise the information to conduct trade. Investors may not trade immediately using their knowledge of information. Rather, they may take several days to complete a trade. Thus computed returns may not reflect the true opening returns but a sum of true returns.

Before the data can be input into the GARCH model, they have to be manipulated. Daily returns $R_{i,t}$ of the indices at time t are expressed as natural logarithm of first difference of closing prices:

$$R_{i,t} = \ln(P_{i,t}) - \ln(P_{i,t-1}) \qquad (4.1)$$

where $P_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, & KOSPI, are the local-currency index price level; and

$P_{i,\,t-1}$ is the one lag value of $P_{i,t}$.

Using natural logarithm instead of percentage price change is supported by three arguments. First, a change in log price is the yield. Second, log price can neutralise any price-level effect. Finally, Fama (1965) finds that changes less than ±15% is very close to the percentage price change. $R_{i,t}$ is considered as a random-walk process if the data is normally distributed with zero mean and constant variance ~ $N(0, \sigma^2)$. Fama (1965) and Granger and Morgenstern (1963) support the hypothesis of random-walk while Kunst et al. (1991) find no evidence to support it.

The next chapter will present the empirical results of the data from the seven financial markets.

CHAPTER V

EMPIRICAL RESULTS

Summary Statistics

Table 3 shows the summary statistics of the index returns of the seven selected stock market indices during full period, pre-crisis, and post-crisis period in Panel A, B, and C respectively. All indices show close-to-zero mean values. S&P 500, Nikkei 225, HSI, and TCI have positive mean values. STII, KLCI, and KOSPI have negative mean values, representing a negative yield on investment portfolio of the indices during the past 5-year period. When the full period is divided into 2 sub-periods, only KOSPI has a pre-crisis negative mean. All indices except for S&P have negative mean values during the post-crisis period. These figures indicate that returns have the most loss during the post-crisis period. HSI shows the greatest drop in mean value from 0.00085 to –0.00042. Differences in standard deviation in pre- and post-crisis period are observed. The differences pinpoint the time varying property of volatility of the indices. In the full sample period, KOSPI has the highest standard deviation. All markets show higher standard deviation during the post-crisis period.

In addition, all indices are skewed since their skewness values deviate from the theoretical value of zero for a normal distribution. S&P 500 and TCI skew to the left

TABLE 3

SUMMARY STATISTICS OF THE STOCK RETURNS

Panel A: Full-Period: 1 June 1995 - 31 May 2000

Statistics	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
Mean (x 10^{-5})	75.100	3.550	33.100	-3.790	-12.400	34.300	-15.100
Median	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	0.050	0.077	0.173	0.149	0.208	0.085	0.100
Minimum	-0.071	-0.072	-0.147	-0.097	-0.242	-0.070	-0.124
S. D.	0.011	0.014	0.020	0.016	0.022	0.016	0.024
Skewness	-0.452	0.055	0.192	0.561	0.582	-0.016	0.097
Kurtosis	7.850	5.785	13.681	14.079	31.491	5.536	5.975
Jarque-Bera	1322.566	422.194	6206.396	6737.626	44179.030	349.553	482.869
p-value of J-B	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	1304	1304	1304	1304	1304	1304	1304

Panel B: Pre-Crisis: 1 June 1995 - 1 July 1997

Statistics	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
Mean (x 10^{-5})	94.500	47.400	85.400	3.660	1.390	84.300	-29.900
Median	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	0.027	0.061	0.044	0.026	0.027	0.054	0.044
Minimum	-0.031	-0.044	-0.076	-0.044	-0.033	-0.070	-0.042
S. D.	0.007	0.012	0.010	0.008	0.009	0.014	0.012
Skewness	-0.408	0.369	-0.676	-0.190	-0.141	-0.267	0.090
Kurtosis	4.730	5.129	9.403	4.893	4.557	5.663	3.780
Jarque-Bera	82.782	114.830	969.067	84.324	56.655	166.921	14.500
p-value of J-B	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
Observations	543	543	543	543	543	543	543

Panel C: Post-Crisis: 1 July 1997 - 31 May 2000

Statistics	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
Mean (x 10^{-5})	61.300	-27.800	-4.240	-9.110	-22.200	-1.330	-4.610
Median	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Maximum	0.050	0.077	0.173	0.149	0.208	0.085	0.100
Minimum	-0.071	-0.072	-0.147	-0.097	-0.242	-0.068	-0.124
S. D.	0.013	0.016	0.024	0.020	0.028	0.017	0.029
Skewness	-0.398	-0.023	0.249	0.518	0.503	0.101	0.075
Kurtosis	6.636	5.530	9.943	10.076	20.926	5.244	4.327
Jarque-Bera	439.283	202.979	1536.254	1621.826	10220.880	160.903	56.549
p-value of J-B	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	761	761	761	761	761	761	761

while Nikkei 225, HSI, STII, KLCI, and TCI skew to the right. Non-zero values of skewness are also found during the pre- and post-crisis periods. Moreover, all indices have a heavy tailed distribution. Their kurtosis values show deviation from the theoretical value 3.0. The corresponding p-values of Jarque-Bera (JB) are also shown. With all low *p*-values, the null hypothesis is rejected at 1 per cent significant level that the returns are normally distribution. Therefore, the indices are not normally distributed, and are highly leptokurtic. The following section will analyze autocorrelation of the return series.

Autocorrelation

Autocorrelation of the log returns and squares of the log returns are shown in Table 4 to Table 6. For the full period level returns, S&P 500 has significant negative and positive autocorrelation starting from lag 7, HSI from lag 3, STII from lag 1, KLCI from lag 4, and KOSPI from lag 1. Nikkei 225 has autocorrelation at lag 1 and lag 2 only. Coefficients are smaller with larger capitalization values, that is, values of S&P 500 and Nikkei 225. All of the coefficients decrease with higher lags, which suggests that the series become more and more stationary over time. For full period squared returns, all indices show strong autocorrelation up to lag 12 in the level returns. For pre-crisis period level returns, only HSI, STII, KLCI, and KOSPI have significant autocorrelation; all indices have significant autocorrelation in their squared returns. The indices follow the same trend whether during post-crisis or during pre-crisis. In the Ljung-Box Q(12) statistic, squares of returns of all indices during each sample period have a Q(12) value greater than the critical value of 21.02. Therefore,

TABLE 4

FULL PERIOD AUTOCORRELATION OF THE STOCK RETURNS

Panel A: Returns in levels							
Statistics	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
ρ_1	0.001	-0.066	0.009	0.159	0.010	0.018	0.108
	[0.975]	[0.017]	[0.751]	[0.000]	[0.706]	[0.520]	[0.000]
ρ_2	-0.019	-0.033	-0.044	-0.003	0.055	0.048	-0.023
	[0.797]	[0.028]	[0.270]	[0.000]	[0.128]	[0.176]	[0.000]
ρ_3	-0.074	-0.005	0.107	0.009	0.033	0.003	-0.038
	[0.055]	[0.065]	[0.001]	[0.000]	[0.138]	[0.323]	[0.000]
ρ_4	-0.009	0.015	-0.062	-0.032	-0.130	-0.059	-0.038
	[0.103]	[0.111]	[0.000]	[0.000]	[0.000]	[0.090]	[0.001]
ρ_5	-0.006	-0.012	-0.022	-0.056	0.070	0.017	-0.068
	[0.170]	[0.174]	[0.000]	[0.000]	[0.000]	[0.134]	[0.000]
ρ_6	-0.024	-0.043	-0.002	-0.029	-0.067	-0.034	-0.041
	[0.201]	[0.122]	[0.001]	[0.000]	[0.000]	[0.128]	[0.000]
ρ_7	-0.080	-0.013	-0.068	-0.049	-0.021	-0.004	0.022
	[0.018]	[0.173]	[0.000]	[0.000]	[0.000]	[0.191]	[0.000]
ρ_8	-0.014	-0.014	-0.001	-0.021	-0.014	0.037	0.047
	[0.029]	[0.230]	[0.000]	[0.000]	[0.000]	[0.161]	[0.000]
ρ_9	-0.017	0.052	0.021	-0.008	-0.015	0.027	0.056
	[0.042]	[0.121]	[0.000]	[0.000]	[0.000]	[0.175]	[0.000]
ρ_{10}	0.061	-0.001	0.067	0.040	0.003	0.020	0.035
	[0.013]	[0.172]	[0.000]	[0.000]	[0.000]	[0.208]	[0.000]
ρ_{11}	-0.024	0.031	0.025	0.056	0.013	-0.028	0.005
	[0.017]	[0.169]	[0.000]	[0.000]	[0.000]	[0.214]	[0.000]
ρ_{12}	0.007	0.030	0.030	0.039	0.052	0.013	-0.037
	[0.026]	[0.170]	[0.000]	[0.000]	[0.000]	[0.266]	[0.000]
L-B(12)	23.266	16.494	37.968	51.779	45.062	14.565	39.123
Observation	1304	1304	1304	1304	1304	1304	1304

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

Figures in parenthesis are p-value statistics

TABLE 4
Continued

Panel B: Squares of Returns							
Statistics	R_{us}^2	R_{jap}^2	R_{hkg}^2	R_{sng}^2	R_{kl}^2	R_{tai}^2	R_{kor}^2
Autocorrelation coefficients							
ρ_1	0.215	0.134	0.385	0.200	0.492	0.074	0.171
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.007]	[0.000]
ρ_2	0.129	0.152	0.168	0.135	0.277	0.162	0.146
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_3	0.053	0.088	0.263	0.139	0.188	0.021	0.212
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_4	0.041	0.133	0.260	0.145	0.214	0.068	0.175
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_5	0.095	0.040	0.141	0.064	0.170	0.054	0.192
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_6	0.119	0.164	0.074	0.051	0.047	0.073	0.125
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_7	0.079	0.066	0.070	0.108	0.050	0.046	0.130
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_8	0.072	0.095	0.032	0.035	0.033	0.040	0.111
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_9	0.070	0.069	0.025	0.018	0.044	0.004	0.115
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_{10}	0.058	0.090	0.069	0.166	0.043	0.130	0.152
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_{11}	0.057	0.006	0.041	0.033	0.085	-0.007	0.141
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_{12}	0.051	0.089	0.048	0.011	0.089	0.012	0.051
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
L-B(12)	152.460	169.040	462.760	193.520	593.690	86.389	349.960
Observation	1304	1304	1304	1304	1304	1304	1304

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

Figures in parenthesis are p-value statistics

TABLE 5

PRE-CRISIS ATUOCORRELATION OF THE STOCK RETURNS

Panel A: Returns in levels

Statistics	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
ρ_1	0.069	-0.052	0.019	0.143	0.133	-0.018	0.152
	[0.107]	[0.226]	[0.665]	[0.001]	[0.002]	[0.680]	[0.000]
ρ_2	-0.010	-0.003	0.073	0.051	0.011	0.050	-0.003
	[0.266]	[0.480]	[0.216]	[0.002]	[0.008]	[0.460]	[0.002]
ρ_3	-0.047	0.031	0.005	-0.018	-0.036	-0.010	0.036
	[0.277]	[0.573]	[0.379]	[0.005]	[0.016]	[0.657]	[0.004]
ρ_4	0.014	-0.007	-0.014	-0.053	-0.069	-0.052	0.021
	[0.410]	[0.732]	[0.526]	[0.007]	[0.011]	[0.538]	[0.009]
ρ_5	-0.029	-0.011	0.033	0.007	-0.046	0.031	-0.076
	[0.489]	[0.838]	[0.578]	[0.014]	[0.015]	[0.599]	[0.005]
ρ_6	-0.016	-0.041	-0.142	-0.041	-0.058	-0.016	-0.077
	[0.600]	[0.807]	[0.021]	[0.019]	[0.013]	[0.703]	[0.003]
ρ_7	-0.028	-0.024	-0.001	-0.008	0.107	-0.078	0.028
	[0.659]	[0.852]	[0.037]	[0.033]	[0.002]	[0.415]	[0.005]
ρ_8	0.008	-0.026	-0.083	-0.084	-0.037	0.024	0.021
	[0.753]	[0.883]	[0.017]	[0.014]	[0.003]	[0.488]	[0.008]
ρ_9	0.033	0.043	-0.016	0.056	0.042	-0.006	-0.033
	[0.776]	[0.858]	[0.027]	[0.013]	[0.004]	[0.587]	[0.011]
ρ_{10}	0.006	0.000	0.063	0.109	-0.008	0.057	0.056
	[0.844]	[0.909]	[0.021]	[0.002]	[0.007]	[0.503]	[0.011]
ρ_{11}	0.008	0.015	-0.020	0.063	0.008	-0.036	0.007
	[0.893]	[0.938]	[0.031]	[0.002]	[0.012]	[0.528]	[0.017]
ρ_{12}	-0.039	0.056	0.095	-0.031	0.033	0.007	-0.092
	[0.888]	[0.881]	[0.010]	[0.003]	[0.016]	[0.612]	[0.006]
L-B(12)	6.522	6.625	26.257	30.193	24.771	10.049	27.719
Observation	543	543	543	543	543	543	543

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

Figures in parenthesis are p-value statistics

TABLE 5
Continued

Panel B: Squares of Returns							
Statistics	R_{us}^2	R_{jap}^2	R_{hkg}^2	R_{sng}^2	R_{kl}^2	R_{tai}^2	R_{kor}^2
Autocorrelation coefficients							
ρ_1	0.029	0.179	0.026	0.144	0.100	0.051	0.110
	[0.497]	[0.000]	[0.547]	[0.001]	[0.019]	[0.229]	[0.010]
ρ_2	0.066	0.099	0.147	0.228	0.041	0.115	0.058
	[0.246]	[0.000]	[0.002]	[0.000]	[0.041]	[0.013]	[0.014]
ρ_3	0.051	0.001	0.025	0.078	0.123	0.056	0.167
	[0.235]	[0.000]	[0.006]	[0.000]	[0.002]	[0.016]	[0.000]
ρ_4	0.081	0.037	0.043	0.106	0.105	0.086	0.120
	[0.095]	[0.000]	[0.009]	[0.000]	[0.000]	[0.006]	[0.000]
ρ_5	0.076	0.015	-0.012	-0.009	0.088	0.065	0.156
	[0.050]	[0.000]	[0.018]	[0.000]	[0.000]	[0.005]	[0.000]
ρ_6	0.118	0.048	0.110	0.100	0.030	0.056	0.080
	[0.005]	[0.000]	[0.002]	[0.000]	[0.000]	[0.005]	[0.000]
ρ_7	0.039	0.079	-0.011	0.007	0.087	0.048	0.056
	[0.007]	[0.000]	[0.005]	[0.000]	[0.000]	[0.006]	[0.000]
ρ_8	-0.021	0.087	0.033	0.087	0.045	-0.023	0.045
	[0.011]	[0.000]	[0.007]	[0.000]	[0.000]	[0.010]	[0.000]
ρ_9	0.131	0.037	-0.016	-0.015	0.060	0.041	-0.023
	[0.001]	[0.000]	[0.012]	[0.000]	[0.000]	[0.013]	[0.000]
ρ_{10}	0.054	0.045	0.017	-0.008	0.052	0.021	0.082
	[0.001]	[0.000]	[0.019]	[0.000]	[0.000]	[0.020]	[0.000]
ρ_{11}	0.131	0.042	-0.012	-0.047	0.111	0.045	0.049
	[0.000]	[0.000]	[0.030]	[0.000]	[0.000]	[0.022]	[0.000]
ρ_{12}	0.103	0.150	0.026	-0.008	0.100	0.012	0.109
	[0.000]	[0.000]	[0.040]	[0.000]	[0.000]	[0.033]	[0.000]
L-B(12)	46.427	47.919	21.755	60.552	46.73	22.411	63.616
Observation	543	543	543	543	543	543	543

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI
$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)
Figures in parenthesis are p-value statistics

TABLE 6

POST-CRISIS AUTOCORRELATION OF THE STOCK RETURNS

Panel A: Returns in levels

Statistics	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
ρ_1	-0.016	-0.073	0.007	0.161	0.002	0.033	0.101
	[0.653]	[0.043]	[0.848]	[0.000]	[0.953]	[0.359]	[0.005]
ρ_2	-0.021	-0.048	-0.059	-0.009	0.058	0.046	-0.026
	[0.761]	[0.054]	[0.257]	[0.000]	[0.275]	[0.288]	[0.015]
ρ_3	-0.081	-0.022	0.119	0.011	0.037	0.008	-0.047
	[0.137]	[0.102]	[0.004]	[0.000]	[0.303]	[0.468]	[0.018]
ρ_4	-0.014	0.022	-0.069	-0.030	-0.134	-0.064	-0.045
	[0.224]	[0.161]	[0.002]	[0.000]	[0.002]	[0.223]	[0.020]
ρ_5	0.000	-0.012	-0.030	-0.063	0.078	0.008	-0.066
	[0.338]	[0.246]	[0.003]	[0.000]	[0.000]	[0.332]	[0.010]
ρ_6	-0.027	-0.045	0.015	-0.027	-0.067	-0.043	-0.037
	[0.397]	[0.219]	[0.006]	[0.000]	[0.000]	[0.304]	[0.013]
ρ_7	-0.093	-0.008	-0.077	-0.053	-0.030	0.029	0.023
	[0.075]	[0.306]	[0.002]	[0.000]	[0.000]	[0.349]	[0.021]
ρ_8	-0.017	-0.008	0.008	-0.014	-0.012	0.042	0.050
	[0.109]	[0.398]	[0.004]	[0.001]	[0.001]	[0.327]	[0.019]
ρ_9	-0.030	0.055	0.026	-0.016	-0.020	0.040	0.068
	[0.131]	[0.296]	[0.006]	[0.002]	[0.002]	[0.318]	[0.009]
ρ_{10}	0.071	-0.002	0.069	0.032	0.003	0.000	0.033
	[0.061]	[0.381]	[0.003]	[0.002]	[0.003]	[0.405]	[0.012]
ρ_{11}	-0.028	0.038	0.030	0.055	0.013	-0.029	0.005
	[0.076]	[0.375]	[0.004]	[0.002]	[0.005]	[0.439]	[0.019]
ρ_{12}	0.015	0.018	0.020	0.047	0.053	0.017	-0.030
	[0.103]	[0.438]	[0.006]	[0.002]	[0.004]	[0.506]	[0.024]
L-B(12)	18.448	12.094	27.950	31.512	29.104	11.265	23.520
Observation	761	761	761	761	761	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

Figures in parenthesis are corresponding p-value statistics

TABLE 6

Continued

Panel B: Squares of Returns							
Statistics	R_{us}^2	R_{jap}^2	R_{hkg}^2	R_{sng}^2	R_{kl}^2	R_{tai}^2	R_{kor}^2
Autocorrelation coefficients							
ρ_1	0.199	0.110	0.373	0.174	0.484	0.071	0.102
	[0.000]	[0.002]	[0.000]	[0.000]	[0.000]	[0.050]	[0.005]
ρ_2	0.104	0.150	0.142	0.106	0.264	0.167	0.076
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_3	0.023	0.093	0.245	0.112	0.174	-0.003	0.147
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_4	0.008	0.141	0.241	0.117	0.201	0.051	0.107
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_5	0.067	0.031	0.117	0.033	0.155	0.039	0.125
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_6	0.090	0.177	0.044	0.019	0.030	0.068	0.052
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_7	0.051	0.047	0.043	0.080	0.034	0.034	0.058
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_8	0.046	0.082	0.002	0.002	0.017	0.049	0.037
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_9	0.037	0.061	-0.005	-0.014	0.028	-0.019	0.042
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_{10}	0.028	0.085	0.040	0.140	0.027	0.155	0.082
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_{11}	0.023	-0.019	0.012	0.002	0.069	-0.037	0.070
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
ρ_{12}	0.018	0.060	0.018	-0.021	0.073	0.001	-0.030
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
L-B(12)	54.627	91.764	227.120	73.599	315.910	54.556	66.264
Observation	761	761	761	761	761	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

Figures in parenthesis are corresponding p-value statistics the null hypothesis that the coefficients of autocorrelation up to lag 12 are jointly zero is rejected at 5 per cent level with 12 degrees of freedom.

Level-Return Correlation

Panel A of Table 7, 8, and 9 shows the cross-index correlation of returns in levels of full sample period, pre-crisis period, and post-crisis period respectively. As seen from the second column of Table 7, there is strong correlation between lagged S&P 500 and all other stock indices. The descending order of strength ranks like this: HSI, STII, Nikkei 225, KLCI, KOSPI, and TCI. When the coefficients of lagged S&P 500 are compared with those of contemporary S&P 500 in the first column, the former effect has a stronger strength than latter. Since New York is $11\frac{1}{2}$-$13\frac{1}{2}$ hours behind Tokyo and Asian markets, the index movement at New York at time t is followed by the other indices that operate at time $t+1$. It can be inferred that Tokyo and the Asian stock markets have little influence on New York market. The strong correlation is due to transmission of knowledge of information from New York to Tokyo and the Asia markets. Second, since the New York Stock Exchange is the world's largest financial market, it is expected to have a strong influence on the world economies and on investors' behaviours. When the three tables are compared, it is found that the correlation between lagged S&P 500 and all other indices becomes stronger during the post-crisis period than before the crisis. For example, the coefficient with Nikkei 225 grows from 0.237 to 0.343, and the Asian average from 0.233 to 0.315.

Nikkei 225 also shows a strong correlation with other stock indices. The descending order of strength is: HSI, S&P 500, STII, KLCI, KOSPI, and TCI. Lagged Nikkei 225, on the other hand, has much smaller correlation with other indices. Since

TABLE 7

FULL SAMPLE PERIOD CROSS CORRELATION OF THE STOCK INDICES

Panel A: Returns in levels

Indices	$R_{us,t}$	$R_{us,t-1}$	$R_{jap,t}$	$R_{jap,t-1}$	$R_{hkg,t}$	$R_{sng,t}$	$R_{kl,t}$	$R_{tai,t}$	$R_{kor,t}$
$R_{us,t}$	1.000								
	[0.000]								
$R_{us,t-1}$	0.001	1.000							
	[0.975]	[0.000]							
$R_{jap,t}$	0.062	0.315	1.000						
	[0.024]	[0.000]	[0.000]						
$R_{jap,t-1}$	-0.025	0.062	-0.066	1.000					
	[0.366]	[0.024]	[0.017]	[0.000]					
$R_{hkg,t}$	0.104	0.403	0.374	-0.037	1.000				
	[0.000]	[0.000]	[0.000]	[0.180]	[0.000]				
$R_{sng,t}$	0.097	0.384	0.309	0.043	0.653	1.000			
	[0.000]	[0.000]	[0.000]	[0.118]	[0.000]	[0.000]			
$R_{kl,t}$	-0.026	0.260	0.210	0.022	0.347	0.407	1.000		
	[0.343]	[0.000]	[0.000]	[0.436]	[0.000]	[0.000]	[0.000]		
$R_{tai,t}$	0.038	0.185	0.162	0.104	0.225	0.236	0.173	1.000	
	[0.175]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	
$R_{kor,t}$	0.077	0.250	0.167	0.058	0.253	0.253	0.198	0.130	1.000
	[0.006]	[0.000]	[0.000]	[0.037]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Asian Avg		0.296	0.244						

Panel B: Squares of Returns

Indices	$R_{us,t}^2$	$R_{us,t-1}^2$	$R_{jap,t}^2$	$R_{jap,t-1}^2$	$R_{hkg,t}^2$	$R_{sng,t}^2$	$R_{kl,t}^2$	$R_{tai,t}^2$	$R_{kor,t}^2$
$R_{us,t}^2$	1.000								
	[0.000]								
$R_{us,t-1}^2$	0.215	1.000							
	[0.000]	[0.000]							
$R_{jap,t}^2$	0.075	0.231	1.000						
	[0.007]	[0.000]	[0.000]						
$R_{jap,t-1}^2$	0.099	0.075	0.134	1.000					
	[0.000]	[0.007]	[0.000]	[0.000]					
$R_{hkg,t}^2$	0.206	0.481	0.230	0.126	1.000				
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]				
$R_{sng,t}^2$	0.150	0.329	0.183	0.071	0.662	1.000			
	[0.000]	[0.000]	[0.000]	[0.011]	[0.000]	[0.000]			
$R_{kl,t}^2$	0.163	0.184	0.115	0.154	0.114	0.143	1.000		
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]		
$R_{tai,t}^2$	0.124	0.147	0.112	0.036	0.197	0.192	0.112	1.000	
	[0.000]	[0.000]	[0.000]	[0.198]	[0.000]	[0.000]	[0.000]	[0.000]	
$R_{kor,t}^2$	0.152	0.226	0.221	0.105	0.247	0.267	0.068	0.123	1.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.013]	[0.000]	[0.000]
Asian Avg		0.273	0.172						

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

Asian Avg stands for the average of cross correlation among the Asian countries not including Japan. The corresponding p-value is given in parenthesis

TABLE 8

PRE-CRISIS CROSS CORRELATION OF THE STOCK INDICES

Panel A: Returns in levels

Indices	$R_{us,t}$	$R_{us,t-1}$	$R_{jap,t}$	$R_{jap,t-1}$	$R_{hkg,t}$	$R_{sng,t}$	$R_{kl,t}$	$R_{tai,t}$	$R_{kor,t}$
$R_{us,t}$	1.000								
	[0.000]								
$R_{us,t-1}$	0.069	1.000							
	[0.109]	[0.000]							
$R_{jap,t}$	0.019	0.237	1.000						
	[0.651]	[0.000]	[0.000]						
$R_{jap,t-1}$	0.042	0.022	-0.052	1.000					
	[0.327]	[0.608]	[0.227]	[0.000]					
$R_{hkg,t}$	0.062	0.456	0.253	0.014	1.000				
	[0.149]	[0.000]	[0.000]	[0.751]	[0.000]				
$R_{sng,t}$	0.094	0.319	0.183	0.085	0.494	1.000			
	[0.029]	[0.000]	[0.000]	[0.048]	[0.000]	[0.000]			
$R_{kl,t}$	-0.001	0.236	0.149	0.038	0.378	0.538	1.000		
	[0.988]	[0.000]	[0.000]	[0.371]	[0.000]	[0.000]	[0.000]		
$R_{tai,t}$	-0.018	0.057	0.064	0.063	0.118	0.065	0.077	1.000	
	[0.682]	[0.187]	[0.134]	[0.142]	[0.006]	[0.132]	[0.072]	[0.000]	
$R_{kor,t}$	0.112	0.098	-0.022	0.018	0.083	0.030	0.018	0.038	1.000
	[0.009]	[0.022]	[0.604]	[0.676]	[0.053]	[0.480]	[0.678]	[0.377]	[0.000]
Asian Avg		0.233	0.125						

Panel B: Squares of Returns

Indices	$R_{us,t}^2$	$R_{us,t-1}^2$	$R_{jap,t}^2$	$R_{jap,t-1}^2$	$R_{hkg,t}^2$	$R_{sng,t}^2$	$R_{kl,t}^2$	$R_{tai,t}^2$	$R_{kor,t}^2$
$R_{us,t}^2$	1.000								
	[0.000]								
$R_{us,t-1}^2$	0.029	1.000							
	[0.499]	[0.000]							
$R_{jap,t}^2$	-0.012	0.070	1.000						
	[0.784]	[0.106]	[0.000]						
$R_{jap,t-1}^2$	-0.009	-0.012	0.179	1.000					
	[0.831]	[0.788]	[0.000]	[0.000]					
$R_{hkg,t}^2$	0.028	0.478	0.083	-0.026	1.000				
	[0.511]	[0.000]	[0.053]	[0.553]	[0.000]				
$R_{sng,t}^2$	0.057	0.294	0.133	-0.002	0.623	1.000			
	[0.186]	[0.000]	[0.002]	[0.960]	[0.000]	[0.000]			
$R_{kl,t}^2$	0.054	0.194	0.097	0.003	0.282	0.421	1.000		
	[0.211]	[0.000]	[0.024]	[0.946]	[0.000]	[0.000]	[0.000]		
$R_{tai,t}^2$	-0.001	-0.045	0.045	0.102	0.039	0.028	0.012	1.000	
	[0.990]	[0.293]	[0.301]	[0.018]	[0.368]	[0.516]	[0.786]	[0.000]	
$R_{kor,t}^2$	0.139	-0.006	0.136	0.178	-0.026	0.040	0.006	0.004	1.000
	[0.001]	[0.886]	[0.001]	[0.000]	[0.544]	[0.356]	[0.891]	[0.919]	[0.000]
Asian Avg		0.183	0.099						

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

Asian Avg stands for the average of cross correlation among the Asian countries not including Japan. The corresponding p-value is given in parenthesis

TABLE 9

POST-CRISIS CROSS CORRELATION OF THE STOCK INDICES

Panel A: Returns in levels

Indices	$R_{us,t}$	$R_{us,t-1}$	$R_{jap,t}$	$R_{jap,t-1}$	$R_{hkg,t}$	$R_{sng,t}$	$R_{kl,t}$	$R_{tai,t}$	$R_{kor,t}$
$R_{us,t}$	1.000 [0.000]								
$R_{us,t-1}$	-0.016 [0.668]	1.000 [0.000]							
$R_{jap,t}$	0.076 [0.036]	0.343 [0.000]	1.000 [0.000]						
$R_{jap,t-1}$	-0.047 [0.195]	0.075 [0.038]	-0.073 [0.043]	1.000 [0.000]					
$R_{hkg,t}$	0.112 [0.002]	0.397 [0.000]	0.415 [0.000]	-0.051 [0.161]	1.000 [0.000]				
$R_{sng,t}$	0.098 [0.007]	0.399 [0.000]	0.349 [0.000]	0.036 [0.321]	0.672 [0.000]	1.000 [0.000]			
$R_{kl,t}$	-0.030 [0.405]	0.269 [0.000]	0.233 [0.000]	0.020 [0.583]	0.346 [0.000]	0.397 [0.000]	1.000 [0.000]		
$R_{tai,t}$	0.056 [0.123]	0.230 [0.000]	0.204 [0.000]	0.121 [0.001]	0.260 [0.000]	0.287 [0.000]	0.202 [0.000]	1.000 [0.000]	
$R_{kor,t}$	0.071 [0.050]	0.279 [0.000]	0.216 [0.000]	0.069 [0.056]	0.274 [0.000]	0.279 [0.000]	0.216 [0.000]	0.158 [0.000]	1.000 [0.000]
Asian Avg		0.315	0.283						

Panel B: Squares of Returns

Indices	$R_{us,t}^2$	$R_{us,t-1}^2$	$R_{jap,t}^2$	$R_{jap,t-1}^2$	$R_{hkg,t}^2$	$R_{sng,t}^2$	$R_{kl,t}^2$	$R_{tai,t}^2$	$R_{kor,t}^2$
$R_{us,t}^2$	1.000 [0.000]								
$R_{us,t-1}^2$	0.199 [0.000]	1.000 [0.000]							
$R_{jap,t}^2$	0.065 [0.071]	0.239 [0.000]	1.000 [0.000]						
$R_{jap,t-1}^2$	0.093 [0.011]	0.065 [0.073]	0.110 [0.002]	1.000 [0.000]					
$R_{hkg,t}^2$	0.187 [0.000]	0.466 [0.000]	0.236 [0.000]	0.124 [0.001]	1.000 [0.000]				
$R_{sng,t}^2$	0.125 [0.001]	0.311 [0.000]	0.180 [0.000]	0.058 [0.111]	0.653 [0.000]	1.000 [0.000]			
$R_{kl,t}^2$	0.147 [0.000]	0.168 [0.000]	0.112 [0.002]	0.157 [0.000]	0.093 [0.010]	0.122 [0.001]	1.000 [0.000]		
$R_{tai,t}^2$	0.130 [0.000]	0.163 [0.000]	0.119 [0.001]	0.005 [0.897]	0.211 [0.000]	0.206 [0.000]	0.117 [0.001]	1.000 [0.000]	
$R_{kor,t}^2$	0.109 [0.003]	0.195 [0.000]	0.214 [0.000]	0.074 [0.040]	0.214 [0.000]	0.233 [0.000]	0.034 [0.344]	0.118 [0.001]	1.000 [0.000]
Asian Avg		0.261	0.172						

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

Asian Avg stands for the average of cross correlation among the Asian countries not including Japan. The corresponding p-value is given in parenthesis

these stock exchanges operate during similar temporal hours, information transmission is immediate. Little old news is being trapped overnight between the markets. However, the stock market in Taipei closes after 12:00PM. Any trading activities in response to afternoon news from Tokyo have to wait until the next day. Thus, the coefficient of lagged Nikkei 225-TCI is stronger than that of Nikkei 225-TCI. The correlations of Japan with the U.S. and with the Asian markets are found to increase during the second sub-period. When these figures are compared with those of the lagged S&P 500, they are smaller in values. For example, the correlation with Asian average increases from 0.125 to 0.283 only. As the world's second largest market after New York, Tokyo's influence continues to play a passive role and to act as a benchmark for the world.

In sum, the lead/lag relationship between the U.S., and Japan, between the U.S. and Asia, and between Japan and Asia are all found to have increased since the Asian financial crisis.

Squared-Return Correlation

Cross-index squared-return correlation is presented in Panel B of Table 7 to Table 9. Lagged S&P 500 has high correlations with Nikkei 225 and with the Asian indices. The effect of strength in descending order is found to be HSI, STII, Nikkei 225, KOSPI, KLCI, and TCI. The correlation of squared-returns has increased since the crisis.

The squared-return correlation between Nikkei 225 and Asian indices shows a similar trend with that of lagged S&P 500. Of course, the magnitudes are smaller overall. The descending order of strength of correlation is found to be S&P 500, HSI, KOSPI, STII, KLCI, and TCI. If volatility is an indication of news transmission, more transmission comes from the U.S. than from Japan. In addition, the magnitude has increased since the crisis.

While all correlations have increased, the percentage of increase in squared-return correlation since the crisis has been higher than the increase in the level-return correlation. For instance, the coefficient between lagged S&P 500 and Nikkei 225 increases sharply from 0.070 (pre-crisis value) to 0.239 (post-crisis value) while the corresponding increase in level-correlation improves from 0.237 to 0.343. Therefore, news transmission affecting volatility has grown at an increasing rate.

Nevertheless, the major disadvantage of linear correlation analysis is that it cannot give a good account for stock returns which exhibit the volatility clustering, skewness, excess kurtosis, and autocorrelation. Since previous results show that all the indices undergo heteroskedastic process, the next step is to use appropriate GARCH model to specify the individual index returns separately. Then the results obtained are used to examine the returns collectively.

GARCH Estimation on Individual Returns

Table 10 is a summary of all GARCH models for easy reference. Table 11, 12, and 13 present the GARCH estimation of parameters of individual returns. This section is going to examine the GARCH model together with mis-specification. GARCH (1,1), GARCH (1,1)-M, and MA(1)-GARCH(1,1)-M have been tried in this analysis.[3] MA (1)-GARCH (1,1)-M is found to be the most parsimonious model based on log-

[3] Bollerslev et al. (1992, p.10) suggest that $p = q = 1$ is sufficient for most financial series.

likelihood function.[4] All different series are then fit into this model for comparison of results. Let's begin by looking at the parameters one by one in the mean equation. The expected returns of S&P 500 are found to be directly proportional to its conditional variance at 1 per cent level during the full and post-crisis periods. The return-risk relationship holds for Nikkei 225, KLCI, and KOSP during pre-crisis period only. The magnitude of KLCI is the strongest, being twice the size of the second highest from KOSPI. Therefore, one may infer that other factors prevail to account for the change in the return-risk relationship in these three indices. DOW is significant for STII and KLCI only but is negative for all three periods. On Monday these two indices are expected to have lower returns than other weekdays, holding other factors constant. However, the magnitudes are very small, and have further decreased after the crisis. The coefficient of MA(1) is significant in HSI, STII, KLCI, and KOSPI. These findings indicate that serial correlation exists in the stock trading. The reason for such a significance may be due to non-synchronous trading or due to some form of market inefficiency (Koutmos and Booth (1995)). HSI is least affected by MA (1) as the exchange imposes no price change limit on daily trading.

[4] Results of other models are not shown.

TABLE 10

SUMMARY OF THE MODELS FOR ESTIMATION OF PARAMETERS

Model 1: MA(1)-GARCH(1,1)-M Individual Return Estimation:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D - \alpha_3 \varepsilon_{t-1} + \varepsilon_t \quad (5.1)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D \quad (5.2)$$

Model 2: Volatility Surprise from the U.S. and Asian countries to Japan:

$$R_{jap,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon_{us,t-1}^2 + \alpha_5 \varepsilon_{hkg,t}^2 + \alpha_6 \varepsilon_{sng,t}^2 + \alpha_7 \varepsilon_{kl,t}^2 + \alpha_8 \varepsilon_{tai,t}^2 + \alpha_9 \varepsilon_{kor,t}^2 - \alpha_{10} \varepsilon_{t-1} + \varepsilon_t \quad (5.3)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_4 \varepsilon_{us,t-1}^2 + \beta_6 \varepsilon_{hkg,t}^2 + \beta_7 \varepsilon_{sng,t}^2 + \beta_8 \varepsilon_{kl,t}^2 + \beta_9 \varepsilon_{tai,t}^2 + \beta_{10} \varepsilon_{kor,t}^2 \quad (5.4)$$

Model 3: Volatility Surprise from Japan and Asian countries to the U.S:

$$R_{us,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_4 \varepsilon_{jap,t}^2 + \alpha_5 \varepsilon_{hkg,t}^2 + \alpha_6 \varepsilon_{sng,t}^2 + \alpha_7 \varepsilon_{kl,t}^2 + \alpha_8 \varepsilon_{tai,t}^2 + \alpha_9 \varepsilon_{kor,t}^2 - \alpha_{10} \varepsilon_{t-1} + \varepsilon_t \quad (5.5)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_5 \varepsilon_{jap,t}^2 + \beta_6 \varepsilon_{hkg,t}^2 + \beta_7 \varepsilon_{sng,t}^2 + \beta_8 \varepsilon_{kl,t}^2 + \beta_9 \varepsilon_{tai,t}^2 + \beta_{10} \varepsilon_{kor,t}^2 \quad (5.6)$$

Model 4: Volatility Surprise from the U.S. and Japan to Asian countries:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon_{us,t-1}^2 + \alpha_4 \varepsilon_{jap,t}^2 - \alpha_5 \varepsilon_{t-1} + \varepsilon_t \quad (5.7)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_4 \varepsilon_{us,t-1}^2 + \beta_5 \varepsilon_{jap,t}^2 \quad (5.8)$$

Model 5: Volatility Surprise from the U.S. to Asian countries:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon_{us,t-1}^2 - \alpha_4 \varepsilon_{t-1} + \varepsilon_t \quad (5.9)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_4 \varepsilon_{us,t-1}^2 \quad (5.10)$$

Model 6: Volatility Surprise from Japan to Asian countries:

$$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon_{jap,t}^2 - \alpha_4 \varepsilon_{t-1} + \varepsilon_t \quad (5.11)$$

$$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_4 \varepsilon_{jap,t}^2 \quad (5.12)$$

where $R_{i,t}$, i = S&P 500, Nikkei 225, HSI, STII, KLCI, TCI, & KOSPI, are the returns;
α_i, β_i, $i = 0,1,2, \ldots 10$ are the constant parameters;
h_t is conditional variance at time t conditioning on all information available at the beginning of time t;
ε_t is the error. In general, ε_t is assumed to be conditionally normally distributed with zero mean and conditional variance h_t at time t:
$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots) \sim N(0, h_t)$
ε_{t-1} is the one lag value of ε_t; and
h_{t-1} represents the one lag value of h_t; D is the DOW dummy variable.

TABLE 11

FULL PERIOD GARCH(1,1) ESTIMATION OF PARAMETERS USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
$\boxed{R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D - \alpha_3 \varepsilon_{t-1} + \varepsilon_t}$							
α_0 (x 10^{-5})	-51.400	-6.850	71.000	21.100	62.300	-47.700	25.100
standard error	0.000	0.001	0.001	0.000	0.000	0.001	0.001
p-value	[0.182]	[0.928]	[0.203]	[0.619]	[0.155]	[0.680]	[0.688]
α_1	16.393	4.148	0.855	2.629	1.086	4.803	0.646
standard error	4.362	4.064	2.003	2.004	1.446	5.424	1.650
p-value	[0.000]	[0.308]	[0.670]	[0.233]	[0.453]	[0.376]	[0.696]
α_2	0.001	-0.002	0.000	-0.002	-0.003	0.001	-0.002
standard error	0.000	0.001	0.001	0.001	0.001	0.001	0.001
p-value	[0.258]	[0.083]	[0.685]	[0.002]	[0.001]	[0.399]	[0.067]
α_3	0.055	-0.054	0.082	0.184	0.114	0.040	0.122
standard error	0.031	0.030	0.033	0.030	0.003	0.033	0.028
p-value	[0.073]	[0.075]	[0.012]	[0.000]	[0.000]	[0.231]	[0.000]
$\boxed{h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D.}$							
β_0 (x 10^{-5})	0.081	0.117	-0.015	-0.515	-0.139	2.250	-1.040
s.e.(x 10^{-5})	0.161	0.325	0.300	0.167	0.127	0.947	0.465
p-value	[0.617]	[0.720]	[0.959]	[0.002]	[0.273]	[0.018]	[0.025]
β_1	0.828	0.913	0.898	0.873	0.885	0.667	0.926
standard error	0.017	0.013	0.010	0.008	0.007	0.059	0.010
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.145	0.066	0.100	0.131	0.119	0.129	0.070
standard error	0.014	0.010	0.012	0.012	0.011	0.024	0.010
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_3 (x 10^{-5})	1.210	1.640	1.600	3.600	1.830	0.000	6.220
s.e.(x 10^{-5})	0.602	1.460	1.340	0.863	0.719	1.450	2.420
p-value	[0.045]	[0.263]	[0.230]	[0.000]	[0.011]	[0.000]	[0.010]
Standardised residuals - $\varepsilon_t/h_t^{1/2}$							
Skewness	-0.612	0.014	-0.294	-0.126	0.139	-0.252	0.071
Kurtosis	5.194	4.960	5.547	5.774	7.903	5.932	4.059
L-B(12)	16.483	6.806	18.792	13.905	14.565	11.126	9.761
Standardised squared residuals - ε_t^2/h_t							
L-B(12)	10.589	8.310	3.584	12.956	3.626	6.185	7.883
Log Likelihood	4161.491	3775.362	3530.623	3844.347	3643.055	3628.528	3288.494
No. of Samples	1304	1304	1304	1304	1304	1304	1304

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

TABLE 12

PRE-CRISIS GARCH(1,1) ESTIMATION OF PARAMETERS
USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
$\boxed{R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D - \alpha_3 \varepsilon_{t-1} + \varepsilon_t}$							
α_0	0.000	-0.002	0.000	0.000	-0.003	-0.002	-0.004
standard error	0.001	0.002	0.002	0.001	0.001	0.002	0.002
p-value	[0.711]	[0.196]	[0.897]	[0.690]	[0.012]	[0.306]	[0.033]
α_1	12.479	23.786	3.881	13.975	61.475	13.610	30.062
standard error	21.500	11.372	21.808	20.271	21.064	9.842	13.847
p-value	[0.562]	[0.037]	[0.859]	[0.491]	[0.004]	[0.167]	[0.030]
α_2 (x 10^{-5})	5.930	-205.800	82.100	-183.000	-207.000	214.000	-230.000
standard error	0.001	0.001	0.001	0.001	0.001	0.001	0.001
p-value	[0.929]	[0.103]	[0.559]	[0.025]	[0.017]	[0.085]	[0.062]
α_3	0.080	-0.071	0.062	0.203	0.120	-0.013	0.145
standard error	0.040	0.044	0.057	0.050	0.047	0.048	0.051
p-value	[0.103]	[0.106]	[0.280]	[0.000]	[0.010]	[0.786]	[0.005]
$\boxed{h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D.}$							
β_0 (x 10^{-5})	0.885	0.667	1.260	0.973	0.491	-0.453	1.260
s.e.(x 10^{-5})	0.342	0.459	1.800	0.615	0.278	0.460	1.020
p-value	[0.010]	[0.146]	[0.485]	[0.114]	[0.077]	[0.324]	[0.216]
β_1	0.738	0.938	0.762	0.642	0.862	0.930	0.731
standard error	0.078	0.017	0.176	0.120	0.040	0.023	0.097
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.115	0.039	0.053	0.125	0.061	0.040	0.103
standard error	0.040	0.010	0.033	0.044	0.019	0.012	0.040
p-value	[0.004]	[0.000]	[0.104]	[0.005]	[0.001]	[0.001]	[0.010]
β_3 (x 10^{-5})	-0.624	-1.870	3.590	1.890	0.075	4.890	5.370
s.e.(x 10^{-5})	0.547	2.200	1.200	0.836	0.996	1.890	2.280
p-value	[0.254]	[0.396]	[0.003]	[0.024]	[0.940]	[0.010]	[0.019]
Standardised residuals - $\varepsilon_t/h_t^{1/2}$							
Skewness	-0.558	0.187	-0.540	-0.114	-0.249	-0.530	0.014
Kurtosis	4.656	4.467	7.913	4.102	4.422	6.884	3.690
L-B(12)	3.699	6.164	21.086	13.015	12.292	9.609	11.469
Standardised squared residuals - ε_t^2/h_t							
L-B(12)	14.959	9.705	6.449	14.911	3.883	2.021	7.958
Log Likelihood	1910.338	1655.486	1723.597	1887.083	1839.955	1577.889	1649.541
No. of Samples	543	543	543	543	543	543	543

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

TABLE 13

POST-CRISIS GARCH(1,1) ESTIMATION OF PARAMETERS USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{us}	R_{jap}	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
	$\boxed{R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D - \alpha_3 \varepsilon_{t-1} + \varepsilon_t}$						
α_0 (x 10^{-5})	-122.000	-47.000	15.100	-24.500	173.300	-4.830	-111.200
standard error	0.001	0.001	0.001	0.001	0.001	0.001	0.002
p-value	[0.304]	[0.716]	[0.920]	[0.841]	[0.102]	[0.971]	[0.589]
α_1	16.254	2.573	1.820	4.810	0.280	2.489	1.490
standard error	8.184	5.600	2.962	3.930	1.760	5.752	2.907
p-value	[0.047]	[0.646]	[0.539]	[0.221]	[0.874]	[0.665]	[0.608]
α_2 (x 10^{-5})	-15.300	-40.800	-145.100	-371.400	-527.400	21.200	0.818
standard error	0.001	0.001	0.002	0.002	0.002	0.002	0.002
p-value	[0.885]	[0.762]	[0.405]	[0.020]	[0.004]	[0.905]	[0.997]
α_3	0.027	-0.043	0.087	0.159	0.121	0.066	0.090
standard error	0.047	0.041	0.044	0.042	0.042	0.042	0.041
p-value	[0.570]	[0.288]	[0.045]	[0.000]	[0.004]	[0.113]	[0.028]
	$\boxed{h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D.}$						
β_0 (x 10^{-5})	1.230	0.352	1.880	-0.233	-1.970	1.010	-4.930
s.e.(x 10^{-5})	0.622	0.624	1.090	0.566	0.682	1.390	1.870
p-value	[0.047]	[0.573]	[0.086]	[0.680]	[0.004]	[0.467]	[0.008]
β_1	0.807	0.889	0.843	0.821	0.858	0.661	0.914
standard error	0.039	0.024	0.017	0.013	0.010	0.066	0.020
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.112	0.071	0.111	0.131	0.131	0.157	0.072
standard error	0.021	0.017	0.017	0.017	0.015	0.033	0.017
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_3 (x 10^{-5})	0.745	3.110	4.150	11.600	16.900	22.000	32.600
s.e.(x 10^{-5})	1.710	2.380	5.500	2.950	3.890	2.680	9.040
p-value	[0.664]	[0.190]	[0.450]	[0.000]	[0.000]	[0.000]	[0.000]
Standardised residuals - $\varepsilon_t/h_t^{1/2}$							
Skewness	-0.569	-0.067	-0.020	0.108	0.686	0.001	0.010
Kurtosis	5.338	5.005	4.742	6.771	9.275	4.334	4.082
L-B(12)	17.676	5.048	13.216	8.949	13.606	6.845	8.173
Standardised squared residuals - ε_t^2/h_t							
L-B(12)	9.164	6.916	5.796	5.521	3.512	12.493	5.049
Log Likelihood	2271.910	2124.648	1822.973	1983.135	1829.020	2062.927	1651.709
No. of Samples	761	761	761	761	761	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%).

In the variance equation, both the coefficients of the GARCH effect and the ARCH effect of all indices are strong and significant at 1 per cent level. Except for TCI, the magnitudes of volatility persistence are similar across all indices which affect its current conditional variance. However, Nikkei 225 and KOSPI are less likely to be affected by its past errors. Such effect persists for all indices after July 1997. TCI has a lower coefficient of volatility persistence during all sample periods. DOW effect is positive and significant in S&P 500, HSI, STII, KLCI, TCI, and KOSPI. These stock markets should generally show higher price fluctuation on Monday than on other weekdays. Such a phenomenon has increased since the financial crisis. While the effect on S&P 500, HSI, and STII are very small, the effect on the other indices is high.

The model for the indices does not show serious mis-specification. There are a few negative constants in the variance equation. They violate the non-negative nature of variance as stated in equation (3.10). Since their values are very small, and some are statistically insignificant, they are regarded as zero. Consequently, they do not present serious problems to the specification of the model in these indices. The LB(12) and $LB^2(12)$ are all smaller than the critical value of 18.55 at 10 per cent with 12 degrees of freedom and they are not significant. Thus, the null hypothesis that the residuals are normally distributed cannot be rejected. In addition, the values of skewness and kurtosis become smaller than those of corresponding returns. However, they are still larger than the theoretical values of 0.0 and 3.0 respectively. Nonetheless, the MA(1)-GARCH(1,1)-M model provides no serious mis-specification for individual index returns. In the next section, the same model is applied to squared residuals from other stock markets. From this section onwards, the focus will be on Volatility Surprise between stock markets. The effects of DOW and MA (1) are not going to be discussed.

Foreign Markets' Volatility Surprises on the U.S and on Japan

Since Model 1 is appropriate to capture the ARCH/GARCH effect, the same model is used to test for volatility surprise. The results are shown in Table 14 in which Model 2 and Model 3 are adopted. The lagged squared residuals are obtained from Model 1. In the mean equation, while Nikkei 225 has no Surprise effect at significant level on S&P 500 during all periods, such effect exists from S&P 500 to Nikkei 225 at 1 per cent level. The strength of Surprise decreased by one half (from –15.008 to –6.328) after July 1997. HSI exports negative Surprise effect and STII exports positive effect to S&P 500 only, but the effects are very small. Nikkei 225 is sensitive to KLCI which has increasing effect on Nikkei 225 after the crisis, and the effect is even smaller than those of HSI and STII. On the other hand, the effect from KOSPI is insignificant after the crisis.

In the variance equation in Panel B of Table 14, the coefficients of conditional variance and error are significant at 1 per cent level for the two indices during the three periods. Both S&P 500 and Nikkei 225 have reciprocal Surprise effects on each other. The magnitude from S&P 500 to Nikkei 225 is much stronger than from Nikkei 225 to S&P 500. All of the effects have decreased since the crisis. The surprise effects from Asian markets are more diverse. After the crisis, only HSI affects S&P 500; while HSI, STII, and KLCI have increasing Surprise effects on Nikkei 225, TCI and KOSPI have decreased their effects slightly after the crisis. When all foreign effects are compared with their own market variances, the former is much weaker than the latter.

No mis-specification is shown from the figures of Q statistic, skewness, and kurtosis. All LB statistic values are smaller than the critical value of 18.55 with 12 degrees of freedom. The next section is going to examine the influence of New York and Tokyo on individual Asian markets.

Foreign Markets' Volatility Surprises on Asian markets

Results of Volatility Surprise on Asian markets are shown in Table 15 to Table 17. First look at the mean equation. While Surprise effect from S&P 500 to KLCI decreases by one third, the effect to STII, TCI, and KOSPI has increased negatively after the crisis. Only KLCI receives negative Surprise effect from Nikkei 225 after the crisis. The effects from S&P 500 are slightly stronger than from Nikkei 225.

Let's turn to the variance equation. Except for that of STII, the persistence to shocks in all other Asian indices has increased after the crisis. The ARCH process of all indices is found to have increased since the crisis. Only HSI is still sensitive to S&P 500 after 1997. However, such effect decreases slightly after the crisis. TCI is insensitive to S&P 500 at all. Nikkei 225 affects TCI and KOSPI before the crisis; after the crisis, HSI, STII, KLCI, and KOSPI are sensitive to its influence. The effects from S&P 500 are higher than those of Nikkei 225. Therefore, S&P 500 and Nikkei 225 have unequal influences across the Asian markets.

TABLE 14

GARCH(1,1) ESTIMATION OF MEAN AND VOLATILITY SURPRISES TO THE U.S. AND JAPAN USING CLOSE-TO-CLOSE RETURNS

Panel A: Mean equation

$$R_{us,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_4 \varepsilon^2_{jap,t} + \alpha_5 \varepsilon^2_{hkg,t} + \alpha_6 \varepsilon^2_{sng,t} + \alpha_7 \varepsilon^2_{kl,t} + \alpha_8 \varepsilon^2_{tai,t} + \alpha_9 \varepsilon^2_{kor,t} - \alpha_{10} \varepsilon_{t-1} + \varepsilon_t$$

$$R_{jap,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon^2_{us,t-1} + \alpha_5 \varepsilon^2_{hkg,t} + \alpha_6 \varepsilon^2_{sng,t} + \alpha_7 \varepsilon^2_{kl,t} + \alpha_8 \varepsilon^2_{tai,t} + \alpha_9 \varepsilon^2_{kor,t} - \alpha_{10} \varepsilon_{t-1} + \varepsilon_t$$

Sampling Periods	Full Period		Pre-Crisis		Post-Crisis	
Coefficients	R_{us}	R_{jap}	R_{us}	R_{jap}	R_{us}	R_{jap}
α_0	0.001	0.001	0.001	-0.001	-0.004	0.001
standard error	0.001	0.001	0.001	0.001	0.002	0.001
p-value	[0.271]	[0.405]	[0.201]	[0.516]	[0.016]	[0.311]
α_1	3.887	2.563	-8.797	12.095	32.987	0.167
standard error	5.519	4.534	16.657	7.495	12.046	4.558
p-value	[0.481]	[0.572]	[0.597]	[0.107]	[0.006]	[0.971]
α_2 (x 10^{-5})	-6.170	-140.000	8.490	-245.200	84.800	48.400
standard error	0.001	0.001	0.001	0.001	0.001	0.001
p-value	[0.906]	[0.118]	[0.894]	[0.045]	[0.449]	[0.706]
α_3	-	-7.402	-	-15.008	-	-6.328
standard error	-	1.445		5.747	-	1.234
p-value	-	[0.000]	-	[0.009]	-	[0.000]
α_4	0.850	-	0.831	-	0.052	-
standard error	0.788	-	1.090		1.156	-
p-value	[0.281]	-	[0.446]	-	[0.964]	-
α_5	-0.737	-0.408	1.527	-0.408	-1.400	-0.135
standard error	0.451	0.544	1.655	2.773	0.614	0.414
p-value	[0.103]	[0.454]	[0.356]	[0.883]	[0.023]	[0.745]
α_6	1.303	0.428	-3.072	0.163	1.509	-0.076
standard error	0.658	0.912	3.602	5.246	0.642	0.865
p-value	[0.048]	[0.639]	[0.394]	[0.975]	[0.019]	[0.930]
α_7	0.296	0.506	3.990	1.719	0.146	0.452
standard error	0.083	0.165	3.421	4.317	0.251	0.227
p-value	[0.000]	[0.002]	[0.244]	[0.691]	[0.561]	[0.047]
α_8	0.701	0.500	0.271	2.017	0.957	-0.224
standard error	0.508	0.756	0.625	1.525	0.849	1.004
p-value	[0.168]	[0.508]	[0.064]	[0.186]	[0.260]	[0.823]
α_9	-0.524	-0.184	-0.722	2.302	-0.281	-0.027
standard error	0.306	0.428	1.437	2.252	0.292	0.400
p-value	[0.086]	[0.667]	[0.616]	[0.307]	[0.336]	[0.946]
α_{10}	0.064	-0.064	0.086	-0.071	0.037	-0.065
standard error	0.032	0.030	0.047	0.052	0.046	0.038
p-value	[0.044]	[0.034]	[0.070]	[0.176]	[0.429]	[0.083]

TABLE 14

Continued

Panel B: Variance equation						
Sampling Periods	Full Period		Pre-Crisis		Post-Crisis	
Coefficients	R_{us}	R_{jap}	R_{us}	R_{jap}	R_{us}	R_{jap}

$$h_{us,t} = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_5 \varepsilon_{jap,t}^2 + \beta_6 \varepsilon_{hkg,t}^2 + \beta_7 \varepsilon_{sng,t}^2 + \beta_8 \varepsilon_{kl,t}^2 + \beta_9 \varepsilon_{tai,t}^2 + \beta_{10} \varepsilon_{kor,t}^2$$

$$h_{jap,t} = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon_{t-1}^2 + \beta_3 D + \beta_4 \varepsilon_{us,t-1}^2 + \beta_6 \varepsilon_{hkg,t}^2 + \beta_7 \varepsilon_{sng,t}^2 + \beta_8 \varepsilon_{kl,t}^2 + \beta_9 \varepsilon_{tai,t}^2 + \beta_{10} \varepsilon_{kor,t}^2$$

β_0 (x 10^{-5})	0.620	1.060	0.702	-0.226	2.620	-1.300
s.e. (x 10^{-5})	0.153	0.297	0.193	0.447	0.797	0.509
p-value	[0.000]	[0.000]	[0.000]	[0.614]	[0.001]	[0.044]
β_1	0.861	0.868	0.730	0.850	0.739	0.994
standard error	0.020	0.023	0.056	0.033	0.059	0.007
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.099	0.059	0.102	0.080	0.085	-0.013
standard error	0.016	0.012	0.030	0.025	0.023	0.006
p-value	[0.000]	[0.000]	[0.001]	[0.002]	[0.000]	[0.028]
β_3 (x 10^{-5})	-2.090	-3.290	-1.330	-3.430	-3.320	2.930
s.e. (x 10^{-5})	0.721	1.460	0.527	1.750	1.840	0.234
p-value	[0.004]	[0.024]	[0.011]	[0.050]	[0.071]	[0.211]
β_4	-	0.040	-	0.063	-	0.015
standard error	-	0.013		0.033	-	0.006
p-value	-	[0.001]	-	[0.054]	-	[0.007]
β_5	-0.006	-	-0.012	-	0.008	-
standard error	0.002	-	0.004		0.011	-
p-value	[0.021]	-	[0.001]	-	[0.472]	-
β_6	0.006	0.014	0.004	-0.004	0.009	0.006
standard error	0.002	0.005	0.006	0.022	0.003	0.001
p-value	[0.000]	[0.010]	[0.561]	[0.861]	[0.002]	[0.000]
β_7	0.002	-0.014	-0.007	0.048	-0.003	-0.010
standard error	0.002	0.006	0.016	0.042	0.004	0.003
p-value	[0.394]	[0.016]	[0.654]	[0.246]	[0.421]	[0.003]
β_8	-0.003	-0.001	0.041	0.036	-0.001	0.002
standard error	0.001	0.002	0.018	0.028	0.002	0.001
p-value	[0.001]	[0.571]	[0.024]	[0.204]	[0.665]	[0.030]
β_9	0.003	0.007	-0.003	0.021	0.012	0.013
standard error	0.002	0.004	0.002	0.009	0.009	0.003
p-value	[0.149]	[0.126]	[0.069]	[0.026]	[0.177]	0.000
β_{10}	0.003	0.004	0.026	0.054	-0.002	0.002
standard error	0.002	0.003	0.008	0.016	0.003	0.001
p-value	[0.056]	[0.125]	[0.002]	[0.001]	[0.425]	[0.022]

Standardised residuals - $\varepsilon_t/h_t^{1/2}$						
Skewness	-0.467	0.153	-0.576	0.132	-0.422	0.145
Kurtosis	4.342	4.154	4.761	3.768	4.415	3.540
L-B(12)	16.195	6.895	3.527	6.554	17.784	9.251
Standardised squared residuals - ε_t^2/h_t						
L-B(12)	7.736	8.449	10.316	14.953	8.428	13.912
Log Likelihood	4193.555	3811.989	1919.741	1670.851	2285.114	2163.970
No. of Samples	1304	1304	543	543	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

TABLE 15

FULL PERIOD GARCH(1,1) ESTIMATION OF MEAN AND VOLATILITY SURPRISES TO THE ASIAN COUNTRIES USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
	$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon^2_{us,t-1} + \alpha_4 \varepsilon^2_{jap,t} - \alpha_5 \varepsilon_{t-1} + \varepsilon_t$				
α_0 (x 10^{-5})	96.400	67.200	183.400	-5.420	21.800
standard error	0.001	0.000	0.000	0.001	0.001
p-value	[0.073]	[0.106]	[0.000]	[0.962]	[0.749]
α_1	2.620	6.564	1.152	3.822	1.738
standard error	2.201	2.527	1.603	5.990	1.729
p-value	[0.234]	[0.009]	[0.472]	[0.523]	[0.315]
α_2	0.001	-0.002	-0.005	0.001	-0.002
standard error	0.001	0.001	0.001	0.001	0.001
p-value	[0.324]	[0.007]	[0.000]	[0.469]	[0.125]
α_3	-8.351	-8.851	-10.367	-5.355	-6.094
standard error	2.155	1.387	1.842	2.055	1.978
p-value	[0.000]	[0.000]	[0.000]	[0.009]	[0.002]
α_4	-0.967	-1.929	-0.518	1.818	0.063
standard error	1.092	0.737	1.193	1.288	1.060
p-value	[0.376]	[0.009]	[0.664]	[0.158]	[0.952]
α_5	0.074	0.178	0.062	0.037	0.120
standard error	0.033	0.030	0.033	0.034	0.030
p-value	[0.027]	[0.000]	[0.062]	[0.287]	[0.000]
	$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon^2_{t-1} + \beta_3 D + \beta_4 \varepsilon^2_{us,t-1} + \beta_5 \varepsilon^2_{jap,t}$				
β_0 (x 10^{-5})	0.091	-0.703	-2.180	3.240	-1.320
s.e. (x 10^{-5})	0.355	0.164	0.121	1.250	0.442
p-value	[0.799]	[0.000]	[0.000]	[0.009]	[0.003]
β_1	0.837	0.863	0.725	0.551	0.930
standard error	0.011	0.010	0.011	0.078	0.011
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.097	0.099	0.184	0.139	0.062
standard error	0.013	0.012	0.016	0.031	0.010
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_3 (x 10^{-5})	-1.150	3.190	18.300	14.200	6.560
s.e. (x 10^{-5})	1.620	0.771	1.800	1.560	2.360
p-value	[0.476]	[0.000]	[0.000]	[0.000]	[0.005]
β_4	0.182	0.065	0.089	0.052	0.041
standard error	0.024	0.010	0.024	0.034	0.014
p-value	[0.000]	[0.000]	[0.000]	[0.121]	[0.005]
β_5	0.024	0.012	0.046	0.039	0.004
standard error	0.010	0.004	0.008	0.015	0.007
p-value	[0.021]	[0.006]	[0.000]	[0.011]	[0.562]

Standardised residuals - $\varepsilon_t/h_t^{1/2}$					
Skewness	0.019	0.247	1.463	-0.110	0.108
Kurtosis	4.500	5.088	18.129	5.529	3.746
L-B(12)	18.380	13.078	26.138	9.860	9.862
Standardised squared residuals - ε_t^2/h_t					
L-B(12)	11.134	14.518	3.771	9.647	12.822
Log Likelihood	3568.433	3884.909	3587.665	3636.550	3294.379
No. of Samples	1304	1304	1304	1304	1304

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

TABLE 16

PRE-CRISIS GARCH(1,1) ESTIMATION OF MEAN AND VOLATILITY SURPRISES TO THE ASIAN COUNTRIES USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
	$\boxed{R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon^2_{us,t} + \alpha_4 \varepsilon^2_{jap,t} - \alpha_5 \varepsilon_{t-1} + \varepsilon_t}$				
α_0 (x 10^{-5})	-113.100	8.540	-835.200	75.900	-278.300
standard error	0.002	0.001	0.004	0.002	0.002
p-value	[0.616]	[0.934]	[0.053]	[0.631]	[0.117]
α_1	28.354	11.834	1.204	-3.454	21.230
standard error	38.491	20.402	0.541	10.680	15.176
p-value	[0.461]	[0.562]	[0.026]	[0.746]	[0.162]
α_2	0.002	-0.002	-0.002	0.003	-0.003
standard error	0.001	0.001	0.001	0.002	0.001
p-value	[0.096]	[0.059]	[0.050]	[0.120]	[0.061]
α_3	-21.290	-6.139	-14.911	2.132	2.720
standard error	26.610	3.775	3.650	5.070	6.339
p-value	[0.424]	[0.104]	[0.000]	[0.674]	[0.668]
α_4	-0.319	-0.862	-0.381	3.374	0.431
standard error	2.466	0.981	1.090	3.930	2.383
p-value	[0.897]	[0.380]	[0.726]	[0.391]	[0.857]
α_5	0.049	0.206	0.107	-0.008	0.146
standard error	0.046	0.047	0.050	0.059	0.052
p-value	[0.289]	[0.000]	[0.032]	[0.899]	[0.005]
	$\boxed{h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon^2_{t-1} + \beta_3 D + \beta_4 \varepsilon^2_{us,t} + \beta_5 \varepsilon^2_{jap,t}}$				
β_0 (x 10^{-5})	4.680	0.662	1.210	2.780	2.320
s.e. (x 10^{-5})	0.794	0.498	0.588	1.420	1.550
p-value	[0.000]	[0.184]	[0.039]	[0.050]	[0.134]
β_1	0.086	0.664	0.725	0.535	0.571
standard error	0.083	0.104	0.092	0.121	0.134
p-value	[0.298]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.042	0.077	0.079	0.133	0.079
standard error	0.033	0.037	0.036	0.055	0.046
p-value	[0.207]	[0.040]	[0.028]	[0.017]	[0.083]
β_3 (x 10^{-5})	-1.640	1.450	-0.278	9.160	7.730
s.e. (x 10^{-5})	0.973	0.886	1.030	2.140	2.290
p-value	[0.093]	[0.102]	[0.788]	[0.000]	[0.001]
β_4	0.672	0.069	0.022	-0.020	0.008
standard error	0.128	0.033	0.022	0.078	0.056
p-value	[0.000]	[0.038]	[0.310]	[0.802]	[0.882]
β_5	0.046	0.010	0.000	0.130	0.069
standard error	0.022	0.007	0.006	0.035	0.027
p-value	[0.034]	[0.134]	[0.978]	[0.000]	[0.010]

Standardised residuals - $\varepsilon_t/h_t^{1/2}$					
Skewness	0.000	0.054	-0.107	-0.309	0.036
Kurtosis	3.992	3.684	4.354	5.704	3.529
L-B(12)	16.672	10.959	14.864	11.374	11.655
Standardised squared residuals - ε_t^2/h_t					
L-B(12)	24.037	10.685	11.274	4.807	9.793
Log Likelihood	1770.312	1891.045	1840.259	1577.420	1649.835
No. of Samples	543	543	543	543	543

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

TABLE 17

POST-CRISIS GARCH(1,1) ESTIMATION OF MEAN AND VOLATILITY SURPRISES TO THE ASIAN COUNTRIES USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
	$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon^2_{us,t-1} + \alpha_4 \varepsilon^2_{jap,t} - \alpha_5 \varepsilon_{t-1} + \varepsilon_t$				
α_0	0.000	0.002	0.003	0.000	0.000
standard error	0.002	0.001	0.001	0.001	0.002
p-value	[0.942]	[0.109]	[0.004]	[0.840]	[0.871]
α_1	1.935	2.516	0.463	4.800	2.580
standard error	4.551	4.499	1.763	6.595	2.957
p-value	[0.671]	[0.576]	[0.793]	[0.467]	[0.383]
α_2	0.000	-0.004	-0.004	0.000	0.001
standard error	0.002	0.002	0.002	0.002	0.002
p-value	[0.894]	[0.129]	[0.051]	[0.849]	[0.837]
α_3	-0.485	-6.071	-4.744	-5.639	-5.887
standard error	5.080	2.167	1.689	2.220	2.669
p-value	[0.924]	[0.005]	[0.005]	[0.011]	[0.027]
α_4	-2.710	-2.173	-5.050	1.770	-3.683
standard error	2.978	1.810	2.284	1.175	2.099
p-value	[0.363]	[0.230]	[0.027]	[0.132]	[0.079]
α_5	0.066	0.146	0.122	0.057	0.096
standard error	0.042	0.043	0.041	0.042	0.041
p-value	[0.120]	[0.001]	[0.003]	[0.175]	[0.021]
	$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon^2_{t-1} + \beta_3 D + \beta_4 \varepsilon^2_{us,t-1} + \beta_5 \varepsilon^2_{jap,t}$				
β_0 (x 10^{-5})	14.500	6.940	-2.920	1.890	-5.090
s.e. (x 10^{-5})	3.500	2.090	0.813	2.130	1.990
p-value	[0.000]	[0.001]	[0.000]	[0.374]	[0.011]
β_1	0.217	0.319	0.844	0.610	0.899
standard error	0.088	0.085	0.011	0.102	0.023
p-value	[0.013]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.123	0.229	0.131	0.144	0.070
standard error	0.035	0.046	0.016	0.037	0.017
p-value	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]
β_3	0.000	0.000	0.000	0.000	0.000
s.e. (x 10^{-5})	3.320	2.290	3.970	2.710	9.820
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.002]
β_4	0.633	0.113	0.022	0.052	0.015
standard error	0.168	0.060	0.025	0.037	0.040
p-value	[0.000]	[0.059]	[0.365]	[0.164]	[0.697]
β_5	0.295	0.120	0.082	0.003	0.076
standard error	0.103	0.048	0.022	0.014	0.032
p-value	[0.004]	[0.012]	[0.000]	[0.826]	[0.017]

Standardised residuals - $\varepsilon_t/h_t^{1/2}$					
Skewness	0.282	0.759	0.875	0.019	0.093
Kurtosis	5.523	8.306	9.312	4.329	3.711
L-B(12)	13.832	13.464	15.779	6.272	10.064
Standardised squared residuals - ε_t^2/h_t					
L-B(12)	25.698	10.665	2.622	14.819	12.716
Log Likelihood	1841.143	1997.424	1847.960	2066.390	1659.869
No. of Samples	761	761	761	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

Comparison of Post-Crisis Individual Effect from 1) the U.S. and 2) Japan

The effect of S&P 500 regressor on the mean and variance equations of the post-crisis Asian indices is shown in Table 18. The corresponding effect from Nikkei 225 index is shown in Table 19. In the mean equation, S&P 500 alone affects all Asian indices except HSI. Nikkei 225 has similar effect on the indices except for TCI. The corresponding magnitudes of influence are generally smaller found in Nikkei 225. In the variance equation, S&P affects all indices while Nikkei 225 cannot influence TCI only. Thus, S&P 500 and Nikkei 225 have different magnitudes of influence on the indices. For example, S&P 500 influences more on HSI and TCI while Nikkei 225 more on STII, KLCI, and KOSPI.

Post-Crisis Collective Effect from the U.S. and Japan

Table 18 and 19 show the individual country effects from U.S. and from Japan respectively. When the figures are compared with those in Table 17 where both country regressors are put together on the Asian indices, the effect of S&P 500 on the mean of STII, KLCI, and KOSPI are weakened. Its effect on the mean of TCI increases, however. The effect from Nikkei 225 is weakened in all Asian markets. On the other hand, KLCI is the only index in which the effect from Nikkei 225 is stronger than from S&P 500. Therefore, common market factor exists between S&P 500 and Nikkei 225.

In the variance equations in the Table 17, 18, and 19, the effect from S&P 500 is found to be weakened across all the Asian indices when that of Nikkei 225 is also taken into account. S&P 500 affects HSI only at the significant level. On the other hand, the effect from Nikkei 225 is found to increase across all the Asian indices except for HSI. Based on these observations, a conclusion can be inferred that the common market factor also plays a role in the variance of the Asian stock indices. Therefore, both the U.S. and Japan are equally important in their influence on Asia.

TABLE 18

POST-CRISIS GARCH(1,1) ESTIMATION OF MEAN AND VOLATILITY SURPRISES FROM THE U.S. TO THE ASIAN COUNTRIES USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
	$R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon^2_{us,t-1} - \alpha_4 \varepsilon_{t-1} + \varepsilon_t$				
α_0 (x 10^{-5})	-31.700	-16.100	244.700	-4.280	-58.900
standard error	0.001	0.001	0.001	0.001	0.002
p-value	[0.822]	[0.895]	[0.024]	[0.976]	[0.769]
α_1	3.429	8.661	0.448	4.933	2.214
standard error	3.072	4.233	1.752	6.584	2.803
p-value	[0.264]	[0.041]	[0.798]	[0.454]	[0.430]
α_2	-0.001	-0.003	-0.004	0.000	0.000
standard error	0.002	0.002	0.002	0.002	0.002
p-value	[0.639]	[0.024]	[0.016]	[0.877]	[0.865]
α_3	-4.758	-9.570	-7.320	-4.889	-7.849
standard error	2.444	1.503	1.794	2.201	2.362
p-value	[0.052]	[0.000]	[0.000]	[0.026]	[0.001]
α_4	0.077	0.161	0.130	0.055	0.096
standard error	0.045	0.041	0.041	0.042	0.041
p-value	[0.084]	[0.000]	[0.002]	[0.194]	[0.019]
	$h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon^2_{t-1} + \beta_3 D + \beta_4 \varepsilon^2_{us,t-1}$				
β_0 (x 10^{-5})	1.260	0.159	-2.670	1.710	-5.570
s.e. (x 10^{-5})	1.180	0.670	0.973	2.080	1.850
p-value	[0.286]	[0.812]	[0.006]	[0.410]	[0.003]
β_1	0.819	0.833	0.856	0.619	0.912
standard error	0.017	0.014	0.010	0.098	0.019
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.102	0.107	0.135	0.140	0.073
standard error	0.017	0.016	0.015	0.035	0.017
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_3 (x 10^{-5})	1.730	4.380	15.100	21.000	30.600
s.e. (x 10^{-5})	6.040	3.070	4.690	2.730	9.570
p-value	[0.775]	[0.153]	[0.001]	[0.000]	[0.001]
β_4	0.185	0.074	0.066	0.059	0.074
standard error	0.048	0.018	0.027	0.037	0.034
p-value	[0.000]	[0.000]	[0.014]	[0.111]	[0.030]

Standardised residuals - $\varepsilon_t/h_t^{1/2}$					
Skewness	0.106	0.441	0.875	0.028	0.076
Kurtosis	4.846	6.034	9.443	4.324	3.738
L-B(12)	16.117	10.304	15.794	6.904	9.111
Standardised squared residuals - ε_t^2/h_t					
L-B(12)	6.946	10.133	4.450	16.093	8.679
Log Likelihood	1831.688	2002.420	1837.536	2065.342	1656.040
No. of Samples	761	761	761	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

TABLE 19

POST-CRISIS GARCH(1,1) ESTIMATION OF MEAN AND VOLATILITY SURPRISES FROM JAPAN TO THE ASIAN COUNTRIES USING CLOSE-TO-CLOSE RETURNS

Coefficients	R_{hkg}	R_{sng}	R_{kl}	R_{tai}	R_{kor}
	$\boxed{R_{i,t} = \alpha_0 + \alpha_1 h_t + \alpha_2 D + \alpha_3 \varepsilon^2_{jap,t} - \alpha_4 \varepsilon_{t-1} + \varepsilon_t}$				
α_0	0.000	0.002	0.003	0.000	-0.001
standard error	0.001	0.001	0.001	0.001	0.002
p-value	[0.851]	[0.184]	[0.006]	[0.846]	[0.812]
α_1	3.176	1.659	0.438	2.487	2.052
standard error	3.078	4.364	1.729	5.888	3.062
p-value	[0.302]	[0.704]	[0.800]	[0.673]	[0.503]
α_2	-0.001	-0.003	-0.003	0.000	0.000
standard error	0.002	0.002	0.002	0.002	0.002
p-value	[0.761]	[0.127]	[0.051]	[0.936]	[0.872]
α_3	-4.632	-3.886	-6.613	0.900	-4.995
standard error	1.660	1.900	2.007	1.103	1.899
p-value	[0.005]	[0.041]	[0.001]	[0.415]	[0.009]
α_4	0.086	0.157	0.116	0.068	0.093
standard error	0.044	0.042	0.041	0.043	0.042
p-value	[0.049]	[0.000]	[0.005]	[0.113]	[0.026]
	$\boxed{h_t = \beta_0 + \beta_1 h_{t-1} + \beta_2 \varepsilon^2_{t-1} + \beta_3 D + \beta_4 \varepsilon^2_{jap,t}}$				
β_0 (x 10^{-5})	2.100	6.200	-2.630	1.240	-4.220
s.e. (x 10^{-5})	1.170	1.930	0.712	1.500	2.030
p-value	[0.072]	[0.001]	[0.000]	[0.410]	[0.038]
β_1	0.802	0.368	0.844	0.642	0.868
standard error	0.018	0.082	0.010	0.073	0.030
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_2	0.112	0.219	0.132	0.159	0.079
standard error	0.018	0.042	0.016	0.035	0.020
p-value	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
β_3 (x 10^{-5})	1.810	21.100	13.500	22.000	31.900
s.e. (x 10^{-5})	6.090	2.190	3.840	2.670	9.700
p-value	[0.766]	[0.000]	[0.000]	[0.000]	[0.001]
β_4	0.100	0.205	0.091	0.011	0.109
standard error	0.038	0.044	0.022	0.016	0.037
p-value	[0.008]	[0.000]	[0.000]	[0.497]	[0.003]

Standardised residuals - $\varepsilon_t/h_t^{1/2}$					
Skewness	0.097	0.720	0.786	-0.006	0.068
Kurtosis	4.697	8.601	9.034	4.356	3.767
L-B(12)	14.103	12.199	15.388	6.468	10.552
Standardised squared residuals - ε_t^2/h_t					
L-B(12)	5.957	6.486	2.029	12.452	12.245
Log Likelihood	1832.081	1994.024	1848.608	2063.451	1660.712
No. of Samples	761	761	761	761	761

us = S&P 500, jap = Nikkei 225, hkg = HSI, sng = STII, kl = KLCI, tai = TCI, and kor = KOSPI

$\chi^2(12)$ critical values: 18.55 (10%), 21.03 (5%), 26.22 (1%)

CHAPTER VI

SUMMARY AND CONCLUSION

The global equity markets have become more integrated internationally. This greater integration occurs as a result of advanced communication technology at low costs and removals of trade barriers among different countries. The stock markets of the U.S., Japan, the Asian Tigers, and Malaysia are chosen to demonstrate such a phenomenon. Performance of stock indices during 1997 presents the factual evidence. The results of this investigation help understand the recent interdependence before and after the Asian financial crisis, and the common market effects and behaviours of the U.S. and Japan during the post-crisis period.

Review of prior research has been done with a view to choosing suitable methods of investigation. Prior research studied the degree of integration process of stock markets during different time intervals. Most of their investigations support the hypothesis that the stock markets are becoming more global over time.

The MA with GARCH (1,1)-in-Mean model is employed to study the unexpected returns of foreign stocks on returns and volatility of domestic stocks based on the assumption put forth by French et al. (1987) and Bollerslev (1987). They assume that the current price is serial correlated to its previous price. In addition, the returns are non-normally distributed and show volatility clustering, skewness, and excess kurtosis. The assumptions of the model obviously violate the theory of random walk process that current price is independent of previous price or past information, and that the returns cannot be predicted by economic agents.

As depicted by the descriptive statistics of the data, the independence assumption is rejected. To account for the heteroskedastic property of stock returns, the GARCH model is most suitable for explaining the Volatility Surprise on the conditional mean and conditional variance of foreign markets. Empirical results show that bi-directional transmissions are found in the markets studied. Surprise effects on price and volatility from the U.S. to Japan have decreased. On the other hand, the price effects of U.S. with Hong Kong and with Singapore have increased. The price effect between Japan and Malaysia is found to have increased. These phenomena can be explained by the differences in trade and in foreign direct investments. For example, Japanese companies have operated more production facilities in Malaysia. Their company performance in Malaysia is more directly linked to that in Japan. Therefore, stock returns are more correlated with each other than with other countries. Another factor is the interest rate differential which puts pressure on short-term stock prices. The interest rate in Hong Kong and Singapore depends on the interest rate in U.S.

In terms of stock price variation, the volatility effects between the U.S. and Hong Kong and between Japan and Hong Kong have increased. The volatility effects of Japan with Singapore and with Malaysia have also increased. On the other hand, the volatility effects of Japan with Taiwan and with Korea have decreased after the crisis. Differences in risk aversion to price movement may account for the results. People are skeptical about investing in Asian countries, especially after the financial crisis. Investors are aware of risks associated with investing in Asian stocks. They are more realistic about what returns they can expect by understanding the markets and their investment goals. Although the returns will be high, the variation in stock price is also large. The investors with high-risk aversion are less likely to invest in financial markets with higher risk, such as Malaysia and Korea. Such behaviours cause differentials in stock volatility among different country pairs. In addition, the results can also be due to change in proportions of technology, media, and telecommunication (TMT) sectors in the stock indices. Taiwan, for instance, has a strong electronics technology base. Therefore, the Taiwanese index involves more risk than others.

In general, the correlation of returns and volatility among the U.S., Japan, Hong Kong, Singapore, and Malaysia is shown to have increased since the crisis. Therefore, the results strengthen the hypothesis that these markets have higher interdependence after the crisis. Hong Kong and Singapore have higher correlation with the U.S. and Japan than other Asian countries. The former countries have similar economic fundamentals upon which the U.S. and Japanese markets have impacts on them at the same time. Both Hong Kong and Singapore are similar in terms of industrial development. The manufacturing and financial services are the two main pillars of Singapore economy, although manufacturing sectors have a less important role in Hong Kong where people emphasize the financial services. Therefore, Hong Kong and Singapore have high correlation with the U.S. and Japanese markets.

Return-risk relationship is found in the U.S., Malaysia, and Korea. DOW on return is found in Japan, Singapore and Malaysia. DOW on variance can be found in all markets. Serial correlation due to non-synchronous trading or market inefficiency is found in all markets except for Taiwan.

Finally, the U.S. and Japan are found to possess common economic forces by comparing their individual and collective influence on the Asian markets. The U.S. has stronger economic impacts than Japan does. These impacts appear to affect the price level and volatility of Asian indices. The relationship between the U.S. and Japan has weakened probably because Japan was both severely affected by its economic conditions and by the Asian crisis. Therefore, the results of correlation and Volatility Surprise suggest that both the U.S. and Japan can help revive the economies of the Asian markets. However, one caution must be taken when interpreting the result. One disadvantage of using close-to-close daily returns is to deal with overlapping of trading hours between Japan and Asian countries. Correlation of returns and volatility should be positively correlated, and is more explained by the ICAPM than by the volatility model. In addition, the Volatility Surprise from Japan is biased downward (e.g. Theodossiou et al. (1997)).

As already mentioned, Japan still plays an important role in the Asian stock markets after the financial crisis. Obviously, Japan has to revive its own economy in order for the Asian markets to leave the current economic recession. After Japan has achieved better economic performance, it can lead the other Asian markets to be prosperous during the post-crisis era. One possible hypothesis for the cause of the Asian Crisis is that Japan has been giving loans to Asian countries. When Japan faces its own domestic economic recession, it cannot afford to lend money further. The Asian countries once depending on Japan have failed to maintain economic growth, causing many of the large construction projects in them to be suspended. As international investors began to be skeptical about these countries' growth potential, they lost confidence in these markets, and withdrew their investment funds in large scale. As a result, the Asian financial crisis broke out.

Japan has to strengthen its monetary policy and to undergo corporate restructuring on its domestic companies. Stronger financial systems enable it to have better investments in promising production which leads to better company performance and hence higher stock prices in the market. The important question is how to revive Japan's economy. Further research may be able to find out the possible factors which affect the Japanese economy. Another possible answer is export to the U.S. and other industrial countries. When these countries demand more imports from Japan, it can make use of its facilities in Southeast Asia where the production costs are generally lower. Such a shift in production also brings about economic growth in these countries, which in turn helps revive Japan. Since Japan's current economic situation is partially caused by the Asian financial crisis, a reviving economy of Japan will contribute to one of the key factors for Asian economic growth.

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